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**TRANSCRIPT OF RECORD**

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**Supreme Court of the United States**

**OCTOBER TERM, [REDACTED] 1938**

**No. [REDACTED] 1**

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**GENERAL TALKING PICTURES CORPORATION,  
PETITIONER,**

**vs.**

**WESTERN ELECTRIC COMPANY, INC., ELECTRICAL  
RESEARCH PRODUCTS, ET AL**

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**ON WRIT OF HABEAS CORPUS TO THE UNITED STATES CIRCUIT COURT  
OF APPEALS FOR THE SECOND CIRCUIT**

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**PETITION FOR HABEAS CORPUS FILED AUGUST 31, 1937.**

**HABEAS CORPUS GRANTED OCTOBER 11, 1937.**

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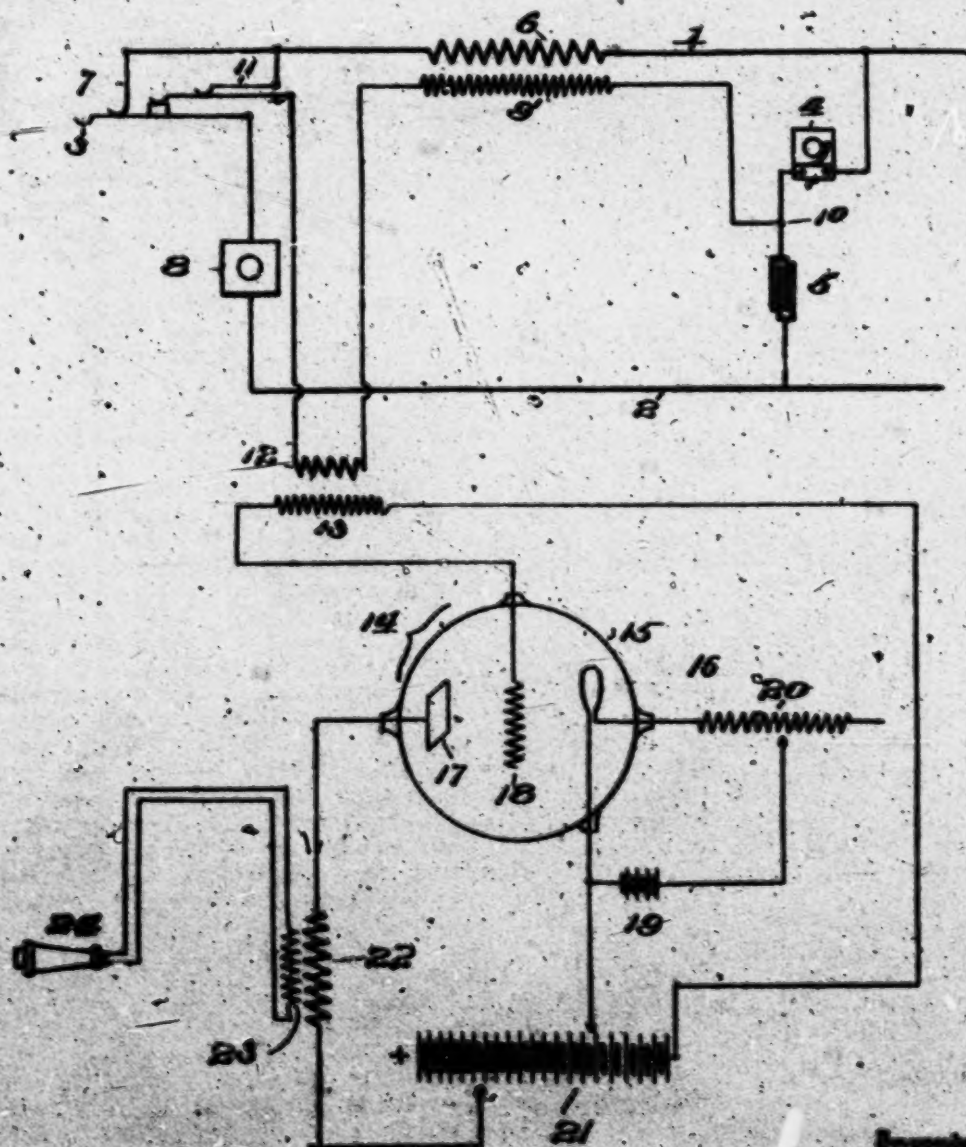
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F. LOWENSTEIN.  
TELEPHONE DELAY.

APPLICATION FILED APR. 24, 1912. DERIVED APR. 26, 1917.

1,231,764.

Patented July 3, 1917.



*Wm. C. Brown*  
Attorney at Law

*F. Lowenstein*  
by *W. C. Brown*  
his attorney

## UNITED STATES PATENT OFFICE

FRANK LOWENSTEIN, OF NEW YORK, N. Y.

TELEPHONE-RELAY.

1,231,764.

Specification of Letters Patent.

Patented July 3, 1917.

Application filed April 24, 1912, Serial No. 692,882. Renewed April 22, 1917. Serial No. 124,787.

*To all whom it may concern:*

Be it known that I, FRANK LOWENSTEIN, a citizen of the United States, residing at New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Telephone-Relays, of which the following is a specification.

My invention relates to improvements in telephone relays.

The object of my invention is to provide a relay by means of which the relation of the potential differences of the complex incoming speech currents is well maintained in the telephone receiver, so that the sound reproduced by the receiver diaphragm will be composed of waves of practically the same frequencies as impinge upon the transmitter diaphragm, and, what I consider most important, these various frequencies will have about the same relative amplitudes as in the original sound waves actuating the transmitter. As a result of this the reproduced sound is intelligible.

It is frequently the case with long distance telephoning that under certain conditions the sound of a speaker's voice may be heard very plainly in the receiver, while at the same time it is unintelligible. As a result of experiments I have ascertained that this lack of intelligibility is due principally to the fact that the speech currents of higher frequencies are attenuated to a greater relative extent than are the speech currents of low frequency due to electrical properties of a long line, so that the incoming speech current is distorted. Furthermore, this distortion is but little affected by terminal conditions, and hence relays or receiving apparatus functioning according to current values cannot remedy the distortion or compensate for the effects thereon.

On the other hand the terminal voltages are materially affected by terminal conditions, and hence it is possible to select such terminal conditions as will enable the relative amplitudes of the original voltages to be well maintained at the incoming end of the line. Therefore, a relay apparatus which functions according to terminal voltages is well adapted for the production of receiver operating currents of the desired absolute strengths and in the relative strengths necessary for the successful operation of the telephone receiver.

My invention will now be explained in connection with one embodiment thereof.

The drawing is a diagrammatic view of so much of one well known form of telephone system as is necessary to explain the construction and operation of my improved relay.

Referring first to the old elements of the system, it will be seen that two wires only, 1 and 2, are used for the three purposes of ringing, microphone operation and transmitting the talking current. When the station is not in use and the receiver is on hook 3 the line 1-2 is connected only through the bridge containing a bell 4 of high self-inductance and a condenser 5 proportioned so as to be in resonance with the self-inductance 4 on 15 cycles, which frequency is used for ringing current.

When the receiver is removed from the hook 3, the line 1-2 is closed also by way of primary 6 of the telephone induction coil, switch contact 7 and microphone 8. On the same core with primary 6 of the induction coil is secondary 9, one terminal of which is connected on the junction point 10 between the bell and condenser of the ringing circuit and the other terminal of which connects through the telephone receiver and contact switch 11 to one side of the primary 6 of the induction coil.

In applying my instrument I substitute for the usual telephone receiver the primary 12 of a step-up transformer which produces in its secondary 13 comparatively high potential. At 14 is an ion or an electron controller, or audion, consisting of a container 15 evacuated and provided with an incandescent filament 16, an anode 17 and a modulating or controlling member 18, which in the present example is a mere grid. Incandescent filament 16 is fed by battery 19 through an adjustable rheostat 20 which permits fine adjustments of the incandescence of the filament. A battery 21 is provided which furnishes current through the evacuated field, the positive pole of the battery being connected to anode 17, a negative point of the battery being connected to filament 16. The potentials created in secondary 13 are made to control the current flowing through the ion field and originating in battery 21 by connecting the one terminal of coil 13 to the modulating member 18 and the other terminal of said coil to a point on the battery 21, which is



located ultranegatively relative to the negative point of the battery connected to the filament. This ultranegative connection is especially desirable and constitutes an important feature of my invention in its preferred embodiment. The volume and clearness of speech as heard in the receiver in the arrangement shown is materially greater than where the grid 18 and coil 19 are connected, for example, to a point at the same potential as the filament 16. The theoretical considerations involved are somewhat abstract and not fully understood; but the advantages of the ultranegative connection is fully established by repeated tests which I have carried out in actual practice. I therefore note the fact without attempting to explain it. Both the positive and the ultranegative points of connection to battery 21 are adjustable to enable variation of the driving potential of battery 21 for the ionic field and of the ultranegative potential. A telephone of many convolutions, may be inserted at 22; but to enable the use of the usual commercial telephone where coil 1, 23 should be a high winding of an induction coil transforming the energy from small current and high potential in coil 28 into a current of lower potential but higher amperage so as to make this energy more available for the commercial telephone receiver 24.

The operation of the ionic controller is as follows:

The incandescent filament 16 produces ionization of the gas contained in container 15 and thereby makes the gas a conductor. The potential between filament 16 and anode 17 derived from battery 21 creates a static field between said filament and anode which exerts a driving power on the ionized gas particles which come in contact with incandescent filament 16 and which are thereby electrically charged. A negative charge in an electric field is acted upon by a force in the direction of the field lines from negative to positive point of the field and the amount of negative current which is therefore conveyed through the field is dependent on the ionization power of the filament, the quantity of the individual charge and the strength of the electric field.

The ionization power of the filament is a function of its temperature and therefore of its incandescence. The individual charge is a function of the negative potential of the filament and also of the degree of evacuation. The intensity of the field is a function of the potential difference between filament and anode and of their distance, which the dependence may therefore be expressed as the potential gradient of the field. Therefore the current in the ionic field circuit will increase with the incandescence of the filament, the potential difference of the battery

and, up to a certain point, with the evacuation.

By providing a modifying or controlling device, such for example as the modulating means 18, which is subjected to an impressed potential more negative than that of the cathode and which is adapted and arranged to interpose between the anode and cathode a modifying or controlling field of the desired character, the potential gradient between the filament and the controlling device or modulating means may be changed and thereby the current which flows through the ionic circuit changed accordingly. By applying variable potentials to the modulating means 18 the currents in the ionic field circuit are varied accordingly and as the impressing of a potential on conductor 18 need not be accompanied by an appreciable expenditure of energy, whereas the energy of the ionic field circuit is varying considerably, I have a means to produce great changes of energy in that field circuit by variation of potentials which do not require appreciable energy.

Having thus fully described my invention, what I claim is:

1. Telephone apparatus comprising the combination, with a talking circuit, of a suitably energized relay circuit including an anode and a cathode separated by a conductive gap, a modulating device interposed in said gap and electrically connected with said talking circuit, means for impressing upon said modulating device a potential more negative than that of said cathode, and a translating device arranged to be energized from said relay circuit.

2. Telephone receiving apparatus, comprising the combination with a talking circuit, of an ionic controller having an anode and a cathode connected in a second circuit electrically related to said talking circuit, a modulating device interposed between said anode and cathode, means for energizing said modulating device from said talking circuit and also from a source of potential which is negative with respect to said cathode, and a telephone receiver arranged to be energized from the controller circuit.

3. Telephone receiving apparatus comprising the combination, with a talking circuit, of an ionic controller having an anode and a cathode suitably spaced apart, a battery, connections from said anode and cathode to the battery, a grid electrically connected to said talking circuit and interposed between said anode and cathode, a connection from said grid to said battery, the battery connection of the grid being negative with respect to the battery connection of the cathode, and a telephone receiver arranged to be energized from the controller circuit.

4. Telephone apparatus comprising the

1,331,784

combination, with a talking circuit, of a co-operating circuit suitably energized and including an anode and a cathode separated by a conductive gap, a modifying or controlling device interposed between said anode and cathode and subjected to an impressed potential more negative than that of said cathode, and a third circuit energized by said cooperating circuit.

10 5. The combination, with an exhausted container, and an anode and a cathode located therein and included in a suitably energized circuit, of a modifying or controlling device interposed between said anode  
15 and cathode and connected to a source of potential more negative than said cathode, and another circuit inductively related to the first mentioned circuit.

20 6. The combination, with an exhausted container, and an anode and a cathode lo-

cated therein and included in a suitably energized circuit, of a modifying or controlling device connected to a source of potential more negative than said cathode and adapted and arranged to influence the character of the field between said anode and cathode, and another circuit inductively related to the first mentioned circuit.

7. The combination, with an audion having its anode and cathode included in a suitably energized circuit, of means for impressing upon the audion grid a potential more negative than that of the audion cathode.

In witness whereof I have hereunto affixed my hand this tenth day of January, 1912.

FRITZ LOWENSTEIN.

Witnesses:

O. F. ROTHEN,  
L. BASCHANG.



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**PAGE**

R. C. MATHES.  
CIRCUITS FOR ELECTRON DISCHARGE DEVICES.  
APPLICATION FILED OCT. 23, 1916.

1,426,754.

Patented Aug. 22, 1922.  
2 SHEETS-SHEET 1.

Fig. 1.

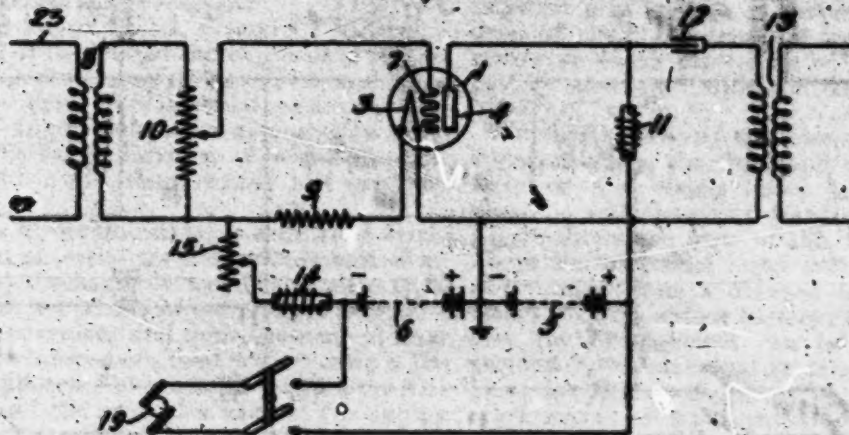
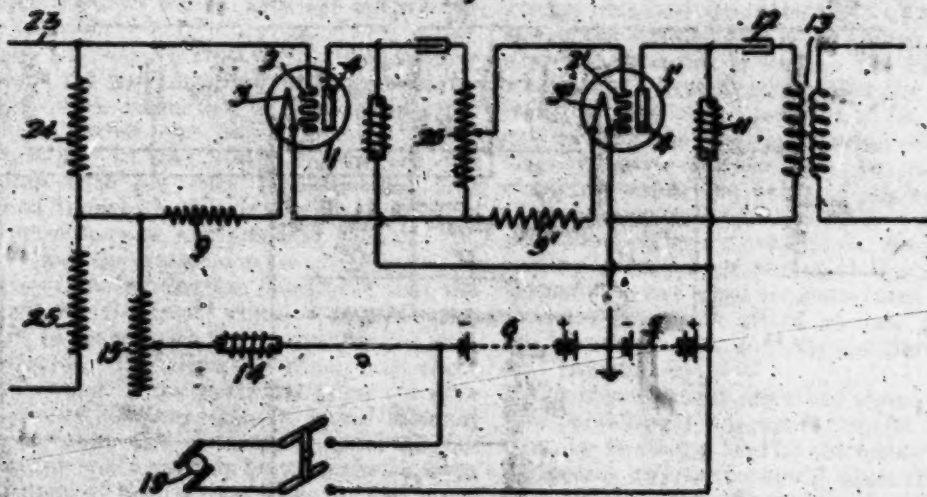


Fig. 2.



Inventor:  
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by *J. E. Roberts* att'y.

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Fig. 3.

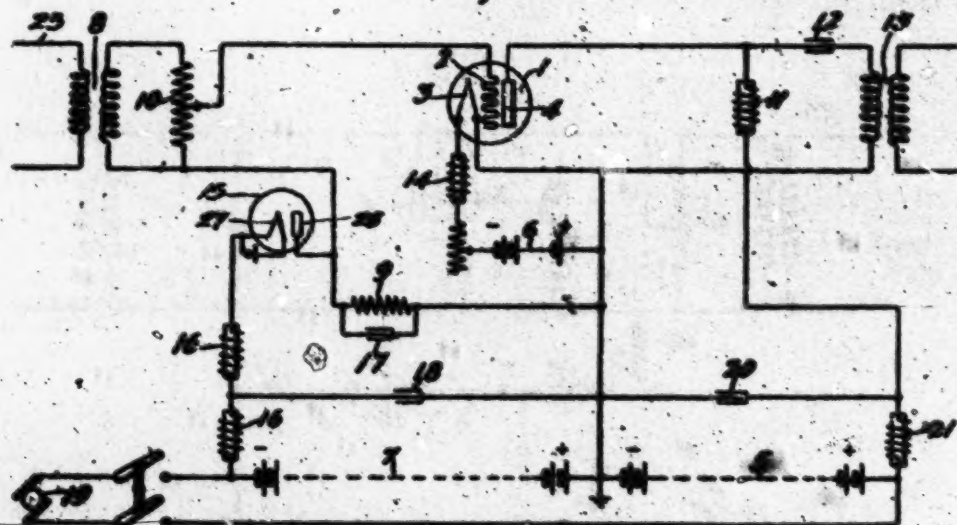
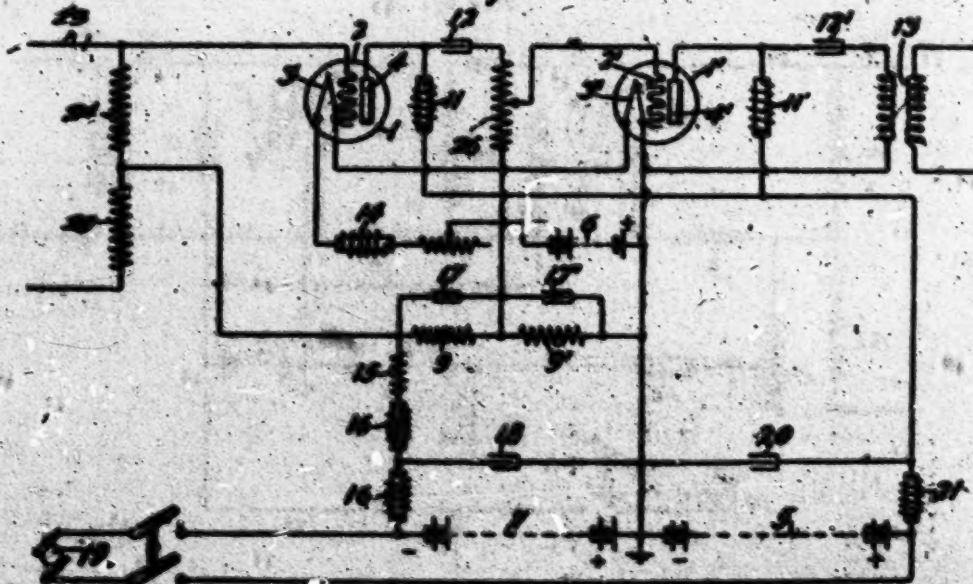


Fig. 4.



Inventor:  
 Robert C. Mathes.

by *J. H. Smith* Att'y.



# UNITED STATES PATENT OFFICE.

ROBERT C. MATHES, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

CIRCUITS FOR ELECTRON-DISCHARGE DEVICES

1,435,754.

Specification of Letters Patent. Patented Aug. 22, 1923.

Application filed October 25, 1922. Serial No. 122,254.

*To all whom it may concern:*

Be it known that I, Robert C. Mathes, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Circuits for Electron-Discharge Devices, of which the following is a full, clear, concise, and exact description.

10 This invention relates to sources of direct current potential for the input circuit of an electron discharge device of the audion type.

An object of the invention is to provide a more convenient and desirable method than 15 has heretofore been used for securing a desired difference of potential between the filament and the grid of a tube of the audion type. A further object is to furnish a method and means for compensating for fluctuations in the potential of the output circuit 20 battery of the vacuum tube.

Specifically, these objects may be realized by the indirect use of the heating battery or of some other source, but in either case 25 associating said source with the output circuit battery.

It is well-known that the current flowing through the output circuit undergoes fluctuations owing to sudden or gradual internal changes within the power battery. Such 30 fluctuations in the space current of the vacuum tube are very troublesome. The method by which this invention overcomes this error may be explained as follows: Assume that the vacuum tube circuits are so 35 arranged, as hereinafter described, that the current for the input circuit comes from a source in series with the source for the output circuit. For illustration, suppose there 40 is a decrease in the potential from the output circuit battery due to some internal change; this will necessarily tend to decrease the space current between the filament and anode of the vacuum tube. If the input 45 and output batteries are of similar nature, this change will in all probability also decrease the potential of the input circuit battery, which is in series with it, so that the grid potential will become less negative 50 thereby tending to increase the space current to its former value. The compensation would take place in a similar manner for an increase in the voltage of the batteries, due, for instance, to the batteries being charged 55 by some suitable means.

This scheme works especially well if the

negative grid voltage is derived from the drop of potential across the terminals of a resistance which derives its current from a battery associated with the output circuit 60 battery.

Further objects of the invention will be apparent from the following detailed description and claims taken in connection with the accompanying drawings in which 65 Fig. 1 shows one form of this invention in which the source of input voltage is indirectly taken from a filament battery associated with the output battery; Fig. 2 shows how the arrangement can be applied to 70 vacuum tubes connected in tandem; Fig. 3 gives another arrangement in which some other source of input voltage is associated with the plate circuit supply; Fig. 4 is the arrangement of Fig. 3 applied to two 75 vacuum tubes in tandem. A similar notation is used in all the figures.

In Fig. 1, 1 is a vacuum tube of the audion type containing a grid 2, a filament 3, and an anode 4. The negative voltage for the 80 grid is obtained from the drop of potential across the terminals of a resistance 5. This drop of potential is due to the battery 6, which is the heating source for the filament 3 and is equal to the product of the filament 85 current and the resistance value of 5. The negative grid voltage may be varied by changing either the value of the resistance 12 or resistance 9. 10 is a battery charging 90 generator. The output circuit, besides containing a source of potential 5 and transformer 12, has also an inductance 11 and capacity 13, which afford an easy path for the direct current and the oscillating cur- 95 rent respectively.

The arrangement described above is therefore particularly adapted to repeat impulses from an incoming line 23 since they may be impressed by transformer 6 upon the resistance 10, the drop of potential across a portion of which is impressed upon the grid 2. 100 The amplified oscillations in the output circuit by transformer 12 may be impressed upon any suitable outgoing line. A choke coil 14 is shown inserted in series with the battery 6 to prevent any variations in its potential from being impressed on the tube 1.

By the variation of the character of resistance 5, more exact compensation can be 110 obtained for the change in the space current of tube 1. If the system gives under-com-

compensation, the resistance should be constituted of iron wire or some other suitable material having a high positive temperature coefficient so that its resistance increases with increase of current. However, if the system gives over-compensation, the resistance may be the impedance of a vacuum tube, an impedance which decreases with increase in current. If considered more convenient, resistance 15 or any part thereof may be made with these variable characteristics, in which case the preceding two sentences apply with the terms of "under-compensation" and "over-compensation" interchanged. It is to be understood, however, that practically good results are obtained by the use of resistances 9 and 15 of ordinary character.

In Fig. 2 we have the scheme of Figure 1 used for two vacuum tubes connected in tandem in a manner now well understood in the art. The negative voltage for grid 2 is due to a drop of potential across the terminals of the resistance 9, while for grid 2' it is due to the drop across the terminals of resistance 9', both resistances being included in the heating circuit of the two filaments which are here arranged in series but may be connected in parallel if desired. Connected across the line 23, are two resistances 24 and 25, only one of which may be associated with the input circuit of the tube 1, if it is desired to impress on the tube only a portion of the total drop of potential across the line 23. The amplified oscillations in the output circuit of tube 1 are impressed by the impedance 26 upon tube 1' which is connected to an outgoing line by transformer 13.

In Fig. 3 the negative grid voltage is supplied from the drop of potential across the terminals of the resistance 9, this drop of potential being due to a source of voltage 7 associated with the battery 5 of the output circuit. In order to keep the grid circuit free from the effects of short, sudden fluctuations arising from the battery 7, it will be desirable, in general, to have a condenser 18 shunted across it and inductance 16 inserted in series with the battery. The effects of similar fluctuations in 5 may be avoided or diminished by a condenser 20 and inductance 21. Condenser 17 may be shunted across 9 to serve as an easy path for the oscillations in the input circuit; and particularly it may be used to minimize crosstalk in case a vacuum tube amplifier of this type is operated from a common battery. Resistance 15 is shown in Fig. 3 in the form of a vacuum tube having a heated filament 27, and an anode 28. This form of impedance for obtaining the desired voltage for the input circuit is preferable in case the arrangement is such that the use of ordinary resistances would give under-compensation, since as is well known, the impedance of a

vacuum tube decreases with increase in current passing therethrough. A similar result may be obtained, as noted above, by employing an ordinary resistance 15 and an iron wire resistance 9, since the iron wire will increase in resistance with increase in current and being in shunt with the grid circuit will take care of any tendency to under-compensation.

In Fig. 4 the same method as in Fig. 3 is illustrated for two vacuum tubes in tandem. The two filaments 3 and 3' are shown connected in series with a heating source 6. The two resistances 9 and 9' are also connected in series, their common source of current being the battery 7. The various condensers and inductances are inserted for reasons previously given. All the resistances shown in these drawings may be of the variable type.

The system may assume still other forms than those herein described without departing in anywise from the spirit of this invention.

It will be noted that the batteries 5 and 6 of Figs. 1 and 2, or the batteries 7 and 5 of Figs. 3 and 4, are of the same type and will therefore be subjected to the same sort of fluctuations. If, for example, these batteries are dry cells, they will gradually drop in voltage as they are used and, as explained heretofore, a gradual drop in the voltage of the output battery will be compensated for by a similar drop in the input battery. If these batteries are storage batteries, there will be a gradual drop in voltage of both input and output batteries during discharge. On closing the switch 19 for charging, there will be a sudden increase in voltage in both batteries followed by a gradual increase during the charging period. In any event any changes common to both batteries tend to compensate each other's effect.

What is claimed is:

1. In an electric translating circuit, an electron discharge device having a heated filament, an anode and a grid, said grid and filament being in the input circuit, a battery for the output circuit, means for bringing the grid to a different potential than the filament, comprising a resistance in the input circuit and a battery for supplying current thereto, the grid-filament steady potential difference being determined substantially solely by the drop in said resistance said means so arranged that gradual fluctuations in the strength of the output battery will be compensated for by fluctuations in the input battery.

2. In an electric translating circuit, an electron discharge device having a heated filament, an anode and a grid, said grid and filament being in the input circuit, a battery for the output circuit, means for bringing the grid to a lower potential than the



filament, comprising a resistance in the input circuit and a battery for supplying current therefor, the grid-filament steady potential difference being determined substantially solely by the drop in said resistance, said means so arranged that the effects of fluctuations in the voltage of the output circuit battery will be minimized by fluctuations in the input circuit battery.

2. In an electric translating circuit, an electron discharge device having a filament, an anode and a grid, said filament and grid being in the input circuit, a resistance in said input circuit, an output battery and an input battery in series, said input battery supplying current to the resistance in the input circuit, the grid-filament steady potential difference being determined substantially solely by the drop in said resistance, said batteries being of such a type as to be subject to the same gradual fluctuations whereby the space current will be substantially independent of said fluctuations and means in series with said batteries for simultaneously charging the same.

3. In an electric translating circuit, an electron discharge device having a filament, an anode and a grid, said filament and grid being in the input circuit, a resistance in said input circuit, an output battery and an input battery in series, said input battery serving as the heating means for the filament and also supplying current to the resistance in the input circuit, the grid-filament steady potential difference being determined substantially solely by the drop in said resistance, said batteries being of such a type as to be subject to the same gradual fluctuations whereby the space current will be substantially independent of said fluctuations and means in series with said batteries for simultaneously charging the same.

4. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, means for normally maintaining said auxiliary electrode at a lower potential than any part of said cathode, said means comprising a resistance shunted by a circuit containing a source of steady voltage, the normal potential difference between the auxiliary electrode and said cathode being determined principally by the drop in said resistance, and a separate source of space current between said cathode and said anode.

5. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, said auxiliary electrode and cathode being in the input circuit of said tube, means for normally maintaining said auxiliary electrode at a lower potential than any part of said cathode, said means comprising a resistance in said input circuit, said resist-

ance being shunted by a source of steady voltage, the normal potential difference between said auxiliary electrode and said cathode being determined principally by the drop in said resistance, and a separate source of space current between said cathode and said anode.

6. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, and means for simultaneously heating said cathode and for bringing said auxiliary electrode to a lower potential than any part of said cathode, the normal potential difference between said auxiliary electrode and said cathode being determined principally by the drop in said resistance.

7. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, said auxiliary electrode and said cathode being in the input circuit of said tube, a source of current connected to said cathode, a resistance, a circuit containing said cathode, said source and said resistance in series, said resistance being also included in the input circuit of said tube in such a manner that the potential of said auxiliary electrode is normally maintained lower than any part of said cathode by an amount substantially equal to the drop in said resistance, said cathode being rendered thermionically active by current flowing in said series circuit.

8. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, said auxiliary electrode and said cathode being in the input circuit of said tube, a source of current connected to said cathode, a resistance connected in series with said source and said cathode, said resistance being also included in the input circuit of said tube, said cathode being rendered thermionically active by current flowing in said series circuit, the normal potential difference between the auxiliary electrode and said cathode being determined principally by the drop in said resistance.

9. In an electric translating circuit, an electron discharge device having a cathode, an anode and an auxiliary electrode, a resistance, a source of steady voltage for said resistance, and means for impressing the drop of potential across said resistance between said auxiliary electrode and said cathode, whereby the potential of said auxiliary electrode is normally maintained lower than any part of said cathode by an amount substantially equal to the drop in said resistance, and a separate source of space current between said anode and said cathode.

10. The combination with a thermionic device, of an iron wire, a source of current for said wire, and means for supplying the

drop of potential across said wire to said device.

12. The combination with a thermionic device having an input circuit of an iron wire, a source of current for said wire, and means for impressing the drop of potential across said wire upon the input circuit of said device.

13. In combination a vacuum tube having cathode, anode and control electrodes, a source of space current therefor, a second source of current, a path containing resistance traversed by current from said second source, and permanent connections from spaced points on said path to said cathode and control electrodes respectively, the minimum normal potential difference between said control electrode and said cathode being maintained substantially equal to the drop in said resistance between said spaced points.

14. In combination a vacuum tube having cathode, anode and control electrodes, a source of space current therefor, a second source of current, a resistance traversed by current from said second source, and permanent connections from the positive and negative ends of said resistance to said cathode and control electrodes respectively, the potential of said control electrode being normally maintained more negative than the negative end of said cathode by an amount substantially equal to the drop in said resistance.

15. The method of controlling the operation of a vacuum tube circuit the input of which is impressed on a grid and in which the potential of the source of space current is subject to variations, which comprises automatically varying the potential of said grid in such a manner as to compensate for said variations.

16. The method of controlling the operation of a vacuum tube circuit the input of which is impressed on a grid and in which the potential of the source of space current is subject to variations, which comprises automatically making the potential of said grid more negative as said source of space current increases in potential.

17. The method of operating a vacuum tube translating device, the operation of which depends on the voltage of a source of current which is variable, which comprises varying the operation of said translating device in a manner complementary to the change in operation due to a fluctuation of said voltage.

18. A vacuum tube apparatus comprising a plurality of tubes arranged in a series and each having a cathode and a grid, and a normally unipotential connection from the grid of one of said tubes to the cathode of another tube.

19. A vacuum tube apparatus comprising

a plurality of tubes arranged in a series and each having a cathode and grid, and a normally unipotential connection from the grid of one of said tubes to the cathode of a preceding tube.

20. A vacuum tube apparatus comprising a plurality of tubes arranged in a series and each having a cathode and grid, and a normally unipotential connection from the grid of one of said tubes to the cathode of the tube next preceding.

21. A vacuum tube apparatus comprising a plurality of tubes arranged in a series and each having a cathode and a grid, and a normally unipotential connection from one grid in the series to the cathode of the first tube of the series.

22. A vacuum tube apparatus comprising a plurality of tubes arranged in a series and each having electrodes, and means for maintaining the potential of an electrode in one of said tubes at a predetermined potential with reference to another electrode of said tube, said means comprising a normally unipotential connection between said electrode and an electrode in a preceding tube of the series.

23. In a multi-stage vacuum tube amplifier in which the anode of one tube is connected conductively to one terminal of a condenser, the other terminal of which is conductively connected to the auxiliary electrode of the next succeeding tube, a connection from said auxiliary electrode to the cathode heating circuit of said succeeding tube, and an impedance in said heating circuit, said auxiliary electrode deriving its steady potential substantially solely from the drop in said impedance.

24. In a multi-stage vacuum tube amplifier, a coupling between two tubes comprising a condenser connected to the anode of one tube and to the auxiliary electrode of the other tube, an impedance between the anode side of the condenser and the space current battery, an impedance between the auxiliary electrode side of the condenser and the filament heating battery, and an impedance between the negative end of the filament of the second tube and said last mentioned impedance.

25. In a vacuum tube amplifier circuit wherein the space current of said amplifier depends upon the voltage of a variable source of current connected to an anode and a cathode, the method which comprises supplying said circuit with at least two impulses, one a compensated impulse derived from an effect produced by variations of said source and the other due to an impulse to be amplified.

26. In a vacuum tube amplifier circuit wherein the space current of said amplifier depends upon the voltage of a variable source of current, the method which com-

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prises supplying said circuit with impulses to be amplified and by passing a portion of the impulses caused by variations in said source of current to a point in the circuit whereby said last mentioned impulses are rendered self-compensatory.

27. A vacuum tube translating device having a cathode and an anode, a source of space current connected to said cathode and

anode, and means responsive to an effect produced by said source of current for changing the impedance of the space between said cathode and said anode in a manner to compensate for changes in said source.

In witness whereof, I hereunto subscribe my name this 9 day of October A. D., 1916.

ROBERT C. MATHES.

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**PAGE**



## PLAINTIFF'S EXHIBIT No. 1 C

H. DE F. ARNOLD.

THERMIONIC AMPLIFIER.

APPLICATION FILED JULY 30, 1919.

Patented Jan. 27, 1920.

2 SHEETS-SHEET 1.

1,399,283.

Fig. 1.

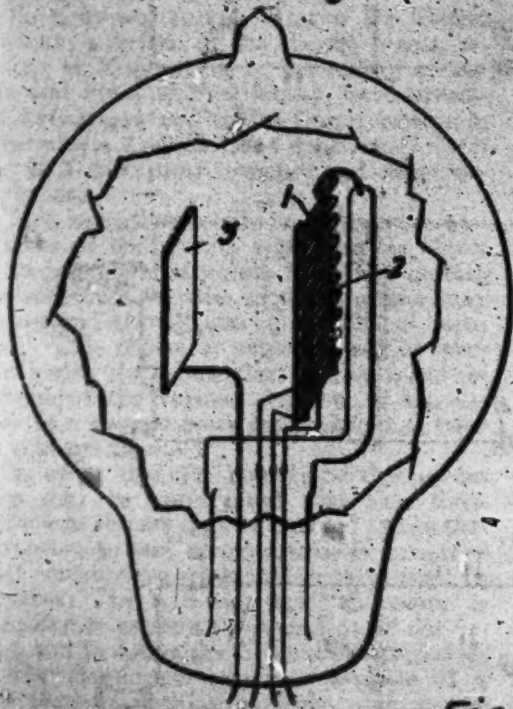


Fig. 2.

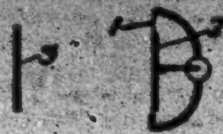


Fig. 3.



Fig. 4.

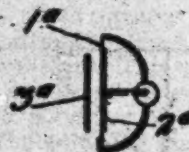


Fig. 5.

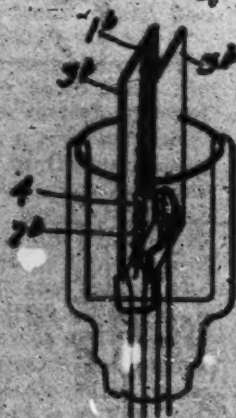


Fig. 6.



Inventor:

Harold D. Arnold.

by *[Signature]*

Att'y.

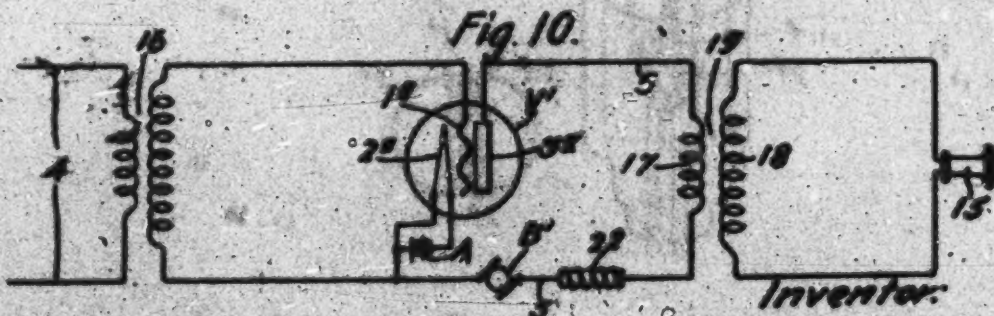
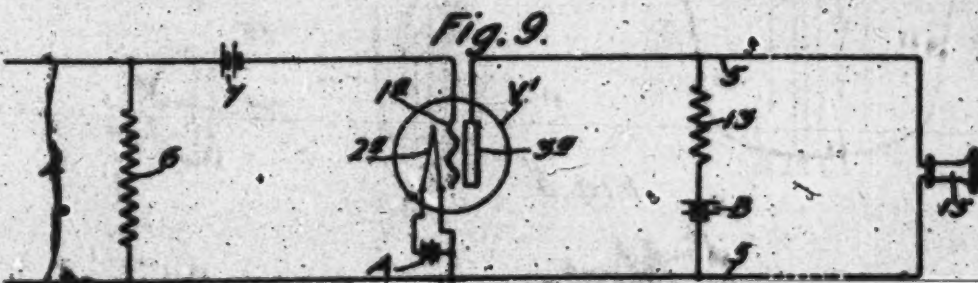
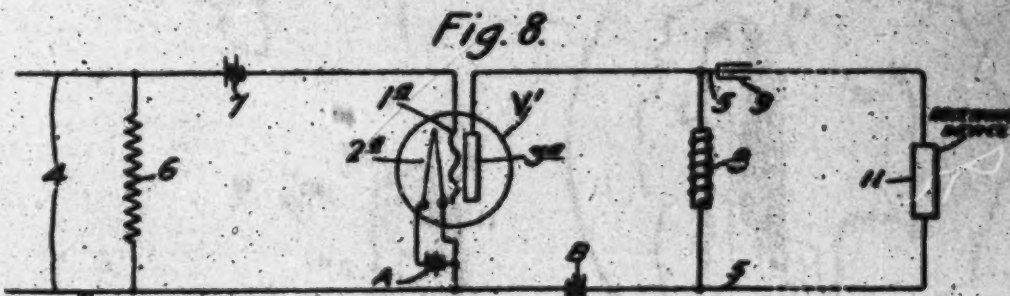
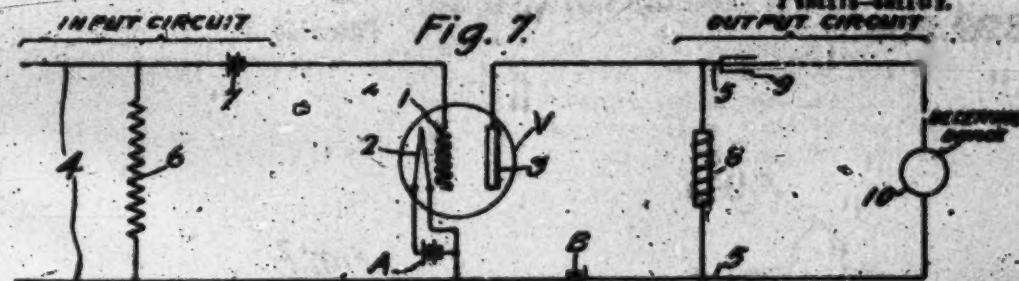
H. DE F. ARNOLD.  
THERMIONIC AMPLIFIER.

APPLICATION FILED JULY 30, 1919.

Patented Jan. 27, 1920.

1,329,283.

2 SHEETS—SHEET 2.



Inventor:  
Harold D. Arnold.  
by *J. H. White* Atty.



# UNITED STATES PATENT OFFICE

HAROLD DE W. ARNOLD, OF HAYLEWOOD, NEW JERSEY, ASSIGNOR TO WESTINGHOUSE ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

IMPROVED AMPLIFIER

1,500,502

Specification of Letters Patent

Patented Jan. 27, 1925.

Be it remembered that in pursuance of application Serial No. 241,271, filed May 22, 1914, and application Serial No. 241,282, filed May 22, 1914, renewed March 2, 1915. This application filed July 22, 1914. Serial No. 241,282.

To all whom it may concern:

Be it known that I, Harold De W. Arnold, a citizen of the United States, residing at Haylewood, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Thermionic Amplifiers, of which the following is a full, clear, concise, and exact description.

This invention relates to thermionic amplifiers of the diode type, and its object is to provide a circuit by which certain desired characteristics of the amplifier may be secured at will and in an efficient manner. This object is accomplished by proportioning the geometrical and electrical relations of the various elements of the device in a manner more fully explained later in this specification.

In order that the novelty of this invention may be appreciated, and that those skilled in the art may be enabled to use this invention to best advantage, it is necessary that certain terms hereinafter used shall be defined. The following brief discussion is intended to explain the operation of the device and to define the terms to be employed.

The thermionic amplifier consists of a hot electron-emitting cathode, such as the so-called "Wehnelt" cathode, of a cool anode and of an auxiliary electrode called the grid, which is usually, though not always, located between the anode and the cathode. A battery is connected so as to force the electrons liberated at the cathode toward the anode, thus setting up a convection current carried by electrons in the evacuated space. In this specification since only the structure of the device itself is under discussion, only the effects of changes in that structure are considered. Obviously a change in the battery will also change the characteristics of the circuit, but in a way which is already known in the art. Due to the presence of these electrons, a negative space charge is established between the cathode and the anode, whose effect is to limit the number of electrons which can leave the cathode, and consequently to limit also the current which can flow in the output circuit, by which is meant the circuit including the battery and the path of the space current. The object of the grid is to furnish a means for introducing a further

negative charge into the space between the cathode and the anode, or for introducing into it a positive charge which shall neutralize the effect of part of the space charge due to the electrons. In the first case, the convection current is decreased; in the second it is increased. In order to force this charge to the grid, a source of electromotive force is connected between grid and cathode, that is, between the least terminals of the device. The effect of such an improved electromotive force is therefore to alter the magnitude of the space current in the amplifier by changing the distribution of space charge between the electrodes, and moreover this is accomplished without requiring that the improved electromotive force shall do more work than that involved in forcing the charge to the grid against the counter voltage of the condenser formed by grid and filament. Thus in this operation the change in power consumed in the output circuit may be much greater than that required in charging the condenser, the device acts as an amplifier. This variation in space current, due to an improved electromotive force, will hereafter be called the output current of the amplifier and the variation in voltage, which appears in the output circuit due to the improved electromotive force, will be called the output voltage. The reason for adopting these definitions is that in the practical applications of the amplifier it is only these variations in current or voltage which are utilized; in fact, a transformer is ordinarily used to derive power from the output circuit, and obviously the steady space current or the steady output voltage have no effect in the secondary of that transformer and may be ignored for practical purposes. Thus, the term voltage amplification means here the ratio of the alternating voltage appearing in the secondary of such a ratio transformer to the alternating voltage impressed across the filament and grid, when the transformer primary is made to include the whole of the output circuit external to the amplifier. In simpler terms, it is the ratio of the above defined output voltage to the impressed input voltage.

There will also be occasion to consider the ratio of output current to input voltage, the latter being taken as standard throughout.

When this ratio is high, other things being the same, the amplifier will be said to be of the high current type, and vice versa. This latter ratio is, of course, not a pure number, but is of the nature of an admittance.

It has been found that amplifiers may be designed for given device conditions so that they will have whatever of the above mentioned characteristics is desired. That is, one may be designed to deliver to a receiving device a comparatively high voltage with a low current, or vice versa. The principles of operation which have been discovered which enable this result to be accomplished may be stated as follows:

In the first place it has been found that it is of advantage to locate the grid as near the cathode as possible whatever the desired voltage amplification or output current. In practice it has been found that when the two elements are separated only by a space enclosing the most efficient action is obtained. Unless there is a solid and continuous spacing element between the two it may be necessary of course to separate them a small distance to prevent arcing caused between them due to focus or up during operation. By saying that the elements are placed as close together as possible it is meant that the distance between them is made as small as possible without introducing appreciable electrical or mechanical disturbances during operation.

Again, it has been found that, when the cathode and grid are placed as near to each other as possible, increasing the distance from the space to the cathode decreases the voltage amplifying power of the tube without at the same time reducing the variable current set up in the output circuit. That is, if we consider two tubes, one of which has the same grid-cathode distance as the other but where the distance between the grid being varied, the cathode is not moved, the tube with the smaller distance is a source of the more variable current and the voltage amplification is higher. If the distance between the grid and cathode is increased, the variable current set up is less and the voltage amplification is lower.

A third principle of operation of the amplifier device which has been discovered may be stated as follows: To increase the voltage amplification of the tube it may be operated at a lower current, and to decrease voltage amplification it is to operate at a higher current, other things being the same.

The character of operation required is another very important factor in determining the type of tube to be used in a given amplifier or receiver. It is found that there is a definite relation between the type of tube and the type of operation required. It is found that the type of tube required for a given type of operation is determined by the type of operation required.

current consumption circuit. This total impedance includes the total line impedance and that of the receiving or transmitting device or device to which power is being supplied.

It has been found that tubes may be constructed in such manner as to take advantage of any number or of all of the above mentioned principles with, of course, correspondingly increased efficiency and adaptability.

An object of this invention is to provide an amplifier, or an equivalent device, which will amplify the variable energy supplied thereto without at the same time causing a large voltage amplification, as is custom of this type amplifier used. Or, differently stated:

To provide an amplifier, or equivalent device, which will cause the amplified energy which appears in the output circuit to take the form of large variable current, rather than smaller variable energy with large voltage amplification.

Another object is to provide an amplifier, or equivalent, using by which a greater impedance ratio is obtained between the impedance of that portion of the output circuit which is without the amplifier and that of the remaining portion of the external circuit, whereby a greatly increased efficiency is obtained.

A further object of the invention is to provide an amplifier, or equivalent device, which will operate with increased efficiency when the transmitting device to which the amplified energy is supplied is the output circuit of the device to use which operates but uses maximum variable current in the amplification, rather than which operates with maximum variable voltage.

Another object of the invention is to provide an amplifier, or equivalent device, which will operate efficiently with a constant speed transmitting device without the use of a voltage transformer between the output and the transmitting device.

Further, namely, the invention provides means for increasing the efficiency of an amplifier, or equivalent device, by using coupling of the transmitted and the current output circuit and the amplifier in a manner, then and with a constant speed transmitting device, by changing the space ratio of the amplifier, the output to space ratio in the grid of the amplifier circuit.

Other and more specific objects of invention will be apparent from the appended claims.

The invention will be more fully understood by reference to the following specification taken in connection with the accompanying drawing in which:

Figure 1 shows the structure of an amplifying tube which is designed to give



greater voltage amplification than those of the prior art; Fig. 2 is a plan view of the amplifier of Fig. 1 arranged to exhibit the geometrical configuration; Fig. 3 is a view of a tube structure designed to give a large output current with low or negative voltage amplification; Fig. 4 is a plan view of the structure of Fig. 3; Figs. 5 and 6 are views corresponding to Figs. 3 and 4 respectively of a modified structure of the new type of amplifier; Fig. 7 is a circuit diagram showing an amplifying system making use of an amplifier of the type shown in Fig. 1; Figs. 8, 9 and 10 are circuit diagrams showing several forms of circuit making use of an amplifier of the kind shown in Fig. 2. In these figures, like numerals represent corresponding parts.

Referring to Figs. 1 and 2, 1 represents the grid element, 2 the cathode or filament and 3 the anode or plate. The plate is placed a considerable distance from the cathode, and the grid is placed very close to the cathode as may be seen therefrom only by a 1" in. section line as, for example, on section 2, cutting on one or the other of the elements. Further, the grid is made to have a fine mesh and thus to obstruct greatly the view of the plate as seen from the cathode.

Figs. 3 and 4 are two views of a thermionic amplifier of the high current type. In these structures, in conformity with the above mentioned principle, the distance from plate 3' to cathode 2' is made very small, and the grid is placed as close as possible to the cathode. Further, the grid 1' is made to have a coarse mesh, or is constructed to have a large ratio of open space to conducting surface, as is required by the conditions above set forth for this type of amplifier.

Figs. 5 and 6 show another modification of the high current type of amplifier. The input electrode or grid is in the form of a wire 1'', bent back at its middle. In effect, therefore, the input electrode consists of two wires joined together. The filament 2'' is wound about the input electrode and is insulated therefrom by a tube of insulating material 4, an arrangement which is not the invention of this applicant, but is described and claimed in Patent 1,120,022 of Jan. 25, 1916 to Alexander McLean Graham. The output electrode or anode consists of two plates 3'', 3'' arranged upon opposite sides of the filament and close to it. It will be noted that the input electrode is not located between the filament and plate, such not being necessary in this high current type of tube.

Fig. 7 is a diagram of an amplifying system in which a tube V of the type shown in Fig. 1 is employed. The tube has the usual input circuit 4, 4 and output circuit 5, 5. The exact arrangement of input and output

circuits is that shown in Patent 1,120,242 to this applicant. In this patent there is shown and claimed a combination of the systems of the type shown in Figs. 7 and 8 respectively of this application, such combination having marked advantages for certain purposes specified in said patent. The purpose of the present application is to specifically describe and claim those types of systems employing novel thermionic amplifiers, these being capable of more general use than that disclosed and claimed in the above mentioned patent.

A source of potential T may be inserted in the input circuit to bring the grid to a desired initial or working potential. No transformer need be used, the incoming line being directly connected to the input electrode, and the outgoing line, to the output electrode. A high resistance element 6 may be connected across the input circuit as shown. A coil 8 of large inductance provides a path for direct current for the tube V, such current being supplied by a source B. The coil 8 will not conduct an appreciable amount of the variable current in the output circuit owing to its high impedance to such current. The condenser 9 is inserted in the line to prevent flow of direct current from the source B through the receiving device 10 if the latter does not itself prevent such flow.

The receiving device 10 may be one which operates most efficiently upon high variable voltage and low current. In accordance with the principles discussed above, the grid 1 and cathode 2 are placed very close together while the plate 3 is widely separated from the cathode, the distance between the two being that necessary to give the desired current and voltage output characteristics. It is usually necessary however for efficient operation to consider first the impedance characteristics of the tube between filament and plate and the receiving device and line, in accordance with the fourth principle of operation stated above. The receiving device 10 is one of high impedance and accordingly the impedance of the tube between filament and plate is made high, the two impedances being made as nearly the same as possible consistent with other possible conflicting requirements. They should at least be of the same order of magnitude, for example one being 100,000 ohms and the other 25,000 ohms. The receiving device 10 may be a novel amplifying tube or similar device.

Fig. 8 is a diagram of a system the same as that of Fig. 7 except that a receiving device having relatively low impedance or operating efficiently upon relatively large variable current and low voltage or both, is present. Accordingly, the anode 3' and cathode 2' of the tube are placed relatively

near together, the grid 1<sup>a</sup> being as before very close to the cathode. The impedance of the amplifier between filament and plate is made the same as that of the receiving device 11, or as nearly the same as other operating conditions will permit, and at least of the same order of magnitude.

It has been found that in accordance with this invention an amplifier of the type shown in FIG. 1 may be constructed which will develop a useful energy of a voltage one third of the voltage of the input energy and having an impedance of the order of 100 ohms. Such an amplifier can then be used directly with a receiving device or may be used with a receiving device of the order of 100 ohms impedance. The receiving device with a receiving device of the order of 100 ohms impedance would be relatively high-impedance higher than that normally obtained.

Fig. 3 shows the same circuit as Fig. 1 except that a high resistance element (25) substituted for the coil 5, this resistance being so large that the variable current through it is negligible. The high-current, low-voltage-amplification type of amplifier is here shown, a tube impedance of the same order as that of the telephone receiver 15 being thus obtained.

30 In Fig. 16 is shown a system similar to that of Fig. 9 except that input and output transformers 18 and 19 respectively, are employed. Except for the tube structure systems of this kind have been in use for some time. The elements of the tube are here spaced and the grid constructed in accordance with the prior art design disclosed, the tube being of the type illustrated in Fig. 2. The impedance of the primary winding 17 of the transformer 18 is low and accordingly the collector-circuit load impedance is made of the same order, the ratio of the number of turns of coil 18 to that of coil 17 being the same as the ratio of the impedance of receiving circuit 19 to that of the primary winding 18. A dynamometer 20 is here placed in the output circuit circuit, it being assumed that the type of output is a current.

[illegible]

By standardizing the amount of power depending on the operation type

current discharge from a heated cathode. It is obvious, however, that the invention might be applied to a discharge device in which other means is employed for liberating electrons from the cathode. In its broader aspect the invention is not limited to the particular structure herein illustrated, but may be found useful in modified forms or types of discharge tubes and in connection with a variety of circuit arrangements.

**What is claimed is:**

1. A vacuum discharge tube having a cathode, an anode and a controlling electrode, said anode being located in such close proximity to the cathode that the tube operates to produce energy amplification without substantial voltage amplification.

27 of thermionic discharge tube having a cathode, an anode, and a controlling electrode, said controlling electrode and said anode being housed in such close proximity to the cathode that the tube operates to produce energy amplification without substantial voltage amplification.

3. A thermionic discharge tube having a cathode, an anode and a controlling electrode, said anode being located in such close proximity to the cathode as to keep the internal impedance of the tube sufficiently low to permit of energy amplification without substantial voltage amplification.

4. The combination with a thermionic discharge tube having a cathode, an anode, and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and transforming means for utilizing the variable current of said output circuit, said cathode being heated by means to both said circuit and said impedance varying element, that, for the impedance and voltage constant within the tube, the tube operates to convert the energy in said input circuit without multiplying the voltage.

4. The combination with a thermionic discharge device having an anode, a cathode and a grid of an input circuit and an output circuit wherein means for producing a variable electrostatic force in said input circuit, a means of electrostatic force in said output circuit and transducing means for utilizing the variable current of said output circuit and cathode being placed so close to said grid and said grid being of such size and shape that, for the magnitudes and relative movement outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the cathode.

The combination with a thermionic discharge tube having a cathode, an anode



and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said impedance varying element being in immediate proximity to the cathode but out of electrical contact therewith, and closer to the cathode than to the anode, so that for the impedances and voltage employed outside the tube, the tube operates to amplify the energy in said input circuit without amplifying the voltage.

7. The combination with a thermionic discharge device having a cathode, an anode and a control element, of an input circuit therefor, and an outgoing circuit having impedance and connected to said anode and cathode, said cathode, anode and control element being so spaced that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit.

8. The combination with a thermionic discharge device, having an anode, a cathode and a control element, of an input circuit therefor, and an outgoing circuit having impedance and connected to said anode and cathode, said cathode, anode and control element being so spaced that the impedance of said discharge device between said anode and said cathode is approximately the same as that of said outgoing circuit.

9. The combination with a thermionic discharge device having a cathode, an anode, and a control element, of an input circuit connected to said cathode and said control element, an outgoing circuit having impedance and connected to said anode and cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said control element but out of electrical contact therewith, and said anode being so spaced from said cathode and control element that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit.

10. The combination with a thermionic discharge device having a cathode, an anode, and a grid of an input circuit connected to said cathode and said grid, an outgoing circuit having impedance and connected to said anode and cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said grid but out of electrical contact therewith, and said anode being so spaced from said cathode

and grid and the said grid being of such coarse mesh that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit.

11. The combination with a thermionic discharge device having a cathode, an anode and a control element, of an input circuit connected to said cathode and said control element, an outgoing circuit having impedance and connected to said anode and cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said control element but out of electrical contact therewith, and said anode being so spaced from said cathode and control element that the impedance of said discharge device between said anode and said cathode is approximately the same as that of said outgoing circuit.

12. The combination with a thermionic discharge device having a cathode, an anode, and a control element, of an input circuit connected to said cathode and said control element, an outgoing circuit having impedance and connected to said anode and said cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode, anode and control element being so placed that the impedance of that portion of the input circuit which is within the discharge device is made as small as possible without introducing disturbing mechanical or electrical variations under working conditions, and the impedance of that part of the outgoing circuit which is within the discharge device is made of the same order as that of the effective impedance of that part of the outgoing circuit which is external to the discharge device.

13. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit.

14. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit

non-magnetically connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit.

15. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit, the variable power delivered to said work circuit being much greater than that supplied by said input circuit, while the variable voltage delivered is correspondingly less than in said input circuit.

16. Means for amplifying energy without substantial voltage amplification, comprising a vacuum discharge tube having an input and an output circuit, a source of variable energy to be amplified connected in said input circuit, and a translating device to which the amplified energy is delivered connected in said output circuit.

17. Means for amplifying energy without substantial voltage amplification comprising an electric discharge device having an anode, a cathode and a current control element, an input circuit and an output circuit for said device, a source of variable energy to be amplified connected in said input circuit, and a translating device to which the amplified energy is delivered connected in said output circuit.

18. Means for amplifying energy without substantial voltage amplification comprising an electric discharge device having an input circuit and an output circuit, a translating device to which the amplified energy is delivered connected in said output circuit, the impedance of that portion of said output circuit which is within said discharge device being of the same order of magnitude as the impedance of said translating device.

19. The combination with an electronic discharge device having an anode, a cathode and an impedance varying element, of an input circuit and an output circuit, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said impedance varying element being in the form of a discontinuous conductive surface, the ratio of conductive surface to open space being so low that, for the impedances and voltages employed outside said device, the device operates to amplify the variable en-

ergy in said input circuit without amplifying the voltage.

20. The combination with an electronic discharge device having a cathode, an anode and a grid, of an input circuit and an output circuit, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said anode being as close to said cathode and said grid being of such coarse mesh that, for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

21. The combination with a thermionic discharge device having a cathode, an anode and a grid, of an input circuit and an output circuit, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode being located in immediate proximity to said grid but out of contact therewith, and the grid being of such coarse mesh that, for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

22. The combination with an electronic discharge device having a cathode, an anode and a grid, of an input circuit and an output circuit, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode being placed in immediate proximity to said grid, but out of contact therewith, said anode being as close to said cathode that for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

23. The combination with an electronic discharge device having a cathode, an anode and an impedance varying element, of an input circuit and an output circuit, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode, anode and impedance varying element being so spaced that for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

24. Means for amplifying energy without substantial voltage amplification comprising



1,222,222

an electric discharge device having an anode, a cathode and a current control element, an input circuit for said device, a source of variable energy to be amplified connected in said input circuit, and a work circuit to which the amplified energy is delivered non-magnetically connected in said output circuit.

25. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode in immediate proximity to said cathode but out of elec-

trical contact therewith and closer to said cathode than to said output electrode.

26. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode as close as possible to said cathode without contacting therewith and closer to said cathode than to said output electrode.

In witness whereof, I hereto subscribe my name this 26th day of July A. D., 1918.

HAROLD D. F. ARNOLD.

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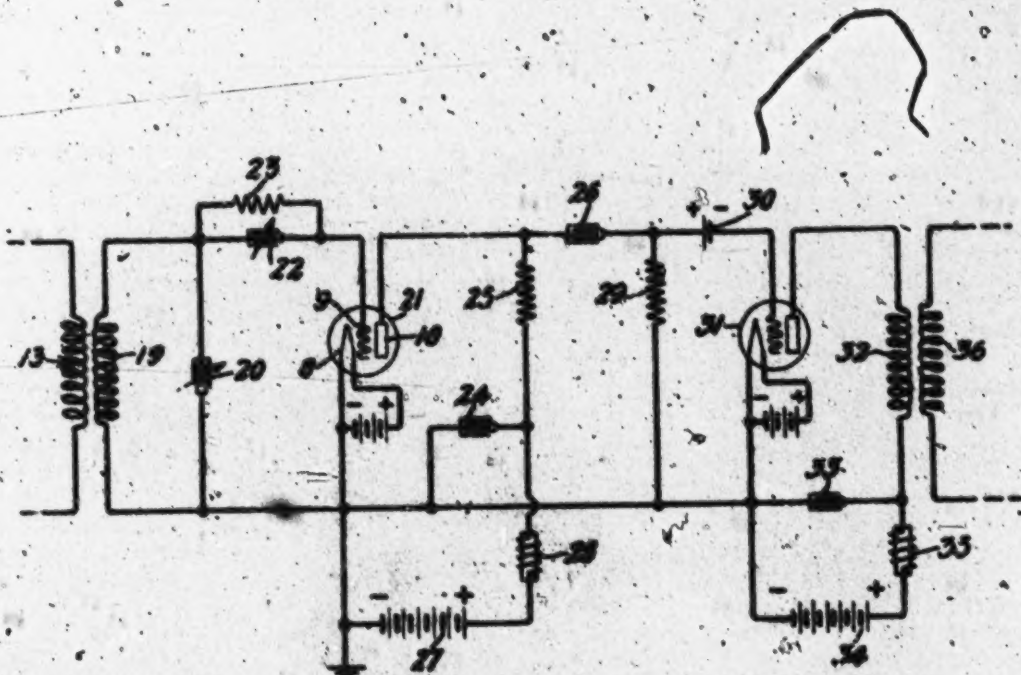
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H. D. ARNOLD.  
VACUUM TUBE CIRCUITS.  
APPLICATION FILED NOV 11, 1920.

1,403,475.

Patented Jan. 17, 1922.



Inventor:  
Harold D. Arnold  
by J. H. R. Att'y.



# UNITED STATES PATENT OFFICE.

HAROLD D. ARNOLD, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## VACUUM-TUBE CIRCUITS.

1,402,472.

Specification of Letters Patent. Patented Jan. 17, 1922.

Original application filed September 2, 1915, Serial No. 48,572. Divided and this application filed November 11, 1920, Serial No. 425,225.

To all whom it may concern:

Be it known that I, HAROLD D. F. ARNOLD, a citizen of the United States, residing at Maplewood, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Vacuum-Tube Circuits, of which the following is a full, clear, concise, and exact description.

This invention relates to vacuum tube circuits and particularly circuits of the type in which a plurality of vacuum tubes are arranged in tandem.

The object of the invention is to provide an improved circuit connection between vacuum tubes whereby fluctuations of current in the output circuit of one vacuum tube may be impressed on the input circuit of another vacuum tube.

In accordance with this invention, the output circuit of a vacuum tube is provided with a path for direct current comprising an impedance, preferably a resistance and the input circuit of the succeeding tube is connected across a portion of the direct current path containing said impedance. A condenser is placed between the direct current circuit and the second tube to prevent the flow of direct current, and a direct connection is also made between the input electrodes of the second tube so that a normal potential difference may be applied therebetween.

This type of connection is also useful for connecting circuits of various kinds either with the input terminals or the output terminals of a vacuum tube.

The invention further resides in the specific details of the circuit hereinafter to be described, and shown in the accompanying drawing, in which the figure represents, schematically, a circuit embodying the invention.

The subject matter of this application is divided out of application Serial No. 48,572, filed September 2, 1915, for radio communication.

Reference numerals are used in this application corresponding to those used in the application above referred to.

This application is a continuation in part of my application Serial No. 247,422, filed

July 30, 1915, now Patent No. 1,329,283, dated January 27, 1920.

Coil 13, which may be connected to any suitable circuit upon which electric impulses may be impressed is inductively connected with the tuned circuit comprising coil 19 and condenser 20. Across the terminals of condenser 20, is connected the input circuit of a detecting device which comprises vacuum tube 21, condenser 22 and resistance 23. For the detection of modulated high frequency signals the purpose of the combination of the condenser and high resistance in connection with vacuum tube 21 is as follows—when a positive charge, for example, is forced upon the grid of element 21, this charge is neutralized by electrons from the filament 8. Then, when a negative charge is forced upon the grid by the incoming wave, this charge adds to that already present and produces a still larger negative charge upon the grid, since the negative charge cannot be neutralized by the electron stream. The condenser, therefore, aids in decreasing the average current in the output circuit. The grid must, however, be conductively connected to the incoming circuit, otherwise the accumulated negative charge would remain and prevent further operation. To provide for this, a high resistance leakage path 23 is shunted around the condenser 22 to allow a leak, slow compared with the period of high frequency currents, but still rapid enough to permit considerable leakage in a time comparable with a period of telephonic waves.

The output circuit of this vacuum tube is supplied with current by battery 27 coming through choke coil 28 and resistance 29, to the anode 10 condenser 24 serving as a high frequency shunt and condenser 25 to limit the direct current to the detector circuit. The amplifier tube 31 has a battery 30 in series with its grid with resistance 29 across its input circuit. The output circuit of amplifier 31 comprises a battery 34 and choke coil 35, both shunted by condenser 23, and a coil 32. Coil 32 is inductively associated with coil 34 may be connected to any suitable circuit for the utilization of the amplified currents.



While a circuit has been shown which is especially adapted for the detection and amplification of modulated high frequency currents, it is obvious that the features of the circuit relating to the object of this invention are adapted for use in repeating electrical impulses of other forms.

What is claimed is:

1. In combination, a vacuum tube having  
10 output electrodes, a path comprising a source of direct current and an impedance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected  
15 across a portion of said first path containing said impedance, and means for applying a steady difference of potential between said input electrodes.
2. In combination, a vacuum tube having  
20 output electrodes, a path comprising a source of direct current and a resistance connected to said electrodes, and a second path comprising a condenser and the input electrodes of a second vacuum tube connected  
25 across a portion of said first path containing said resistance, and means for applying a steady difference of potential between said input electrodes.
3. In combination, a vacuum tube having  
30 output electrodes, a path comprising a source of direct current and an impedance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected  
35 across a portion of said first path containing said impedance, and a conductive path between the input electrodes of said second tube.
4. In combination, a vacuum tube having  
40 output electrodes, a path comprising a source of direct current and a resistance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected  
45 across a portion of said first path containing said resistance, and a conductive path between the input electrodes of said second tube.
5. In combination, a vacuum tube having  
50 output electrodes, a path comprising a source of direct current and a resistance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected  
55 across a portion of said first path comprising said resistance and said source of direct potential, and a conductive path between the input electrodes of said vacuum tube.
6. In combination, two vacuum tubes, a circuit connecting the output electrodes of one of said tubes to the input electrodes of the other of said tubes, said circuit comprising a series condenser and a shunt impedance at each side of said condenser.

7. In combination, two vacuum tubes, a circuit connecting the output electrodes of one of said tubes to the input electrodes of the other of said tubes, said circuit comprising a series condenser and a shunt path at each side of said condenser, each of said paths comprising a resistance.

8. In combination a circuit comprising a resistance and means for producing potential variations across said resistance, a vacuum tube having input electrodes, and connections for impressing said variations on said electrodes, said connections comprising a series condenser.

9. In combination, a circuit comprising a resistance, a source of direct current and means for producing variations in said current, a vacuum tube having input electrodes, and connections for impressing said variations on said electrodes, said connections comprising a series condenser.

10. In combination, a circuit comprising a resistance and means for producing potential variations across said resistance, a vacuum tube having input electrodes, connections for impressing said variations on said electrodes, said connections comprising a series condenser, and a resistance shunt for said input electrodes.

11. In combination, a circuit for the reception of modulated high frequency currents, a vacuum tube for detecting and amplifying said currents, said vacuum tube having an impedance in its output circuit, and a circuit connected substantially in parallel with said impedance for impressing variations in the output circuit on another amplifier, said second circuit comprising a series condenser.

12. In combination, a circuit for the reception of modulated high frequency currents, a vacuum tube for detecting and amplifying said currents, said vacuum tube having an impedance in its output circuit, a circuit connected substantially in parallel with said impedance for impressing variations in the output circuit on another amplifier, said second circuit comprising a series condenser, and a shunt conductance.

13. A detector and amplifier of high frequency currents having in its output circuit a source of direct current, an inductance and a resistance in series, an amplifier having its input circuit in parallel with said series circuit, and a path of low impedance having one terminal in common with said circuits, and its other terminal connected between said resistance and said inductance.

14. A detector and amplifier of high frequency currents having in its output circuit a source of current and an inductance, a translating device having an input circuit connected in parallel to a portion of said output circuit containing said inductance, and a path of low impedance to high frequency

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quency current connected in parallel to a portion of said output circuit containing said inductance.

15. In combination, a vacuum tube having output electrodes, a path for direct current comprising said output electrodes, a source of current and an impedance, and a path for alternating currents comprising a condenser

and a work circuit, said second path being in parallel to a portion of said first path 10 containing said impedance.

In witness whereof, I hereunto subscribe my name, this 5th day of November, A. D. 1920.

HAROLD D. ARNOLD.

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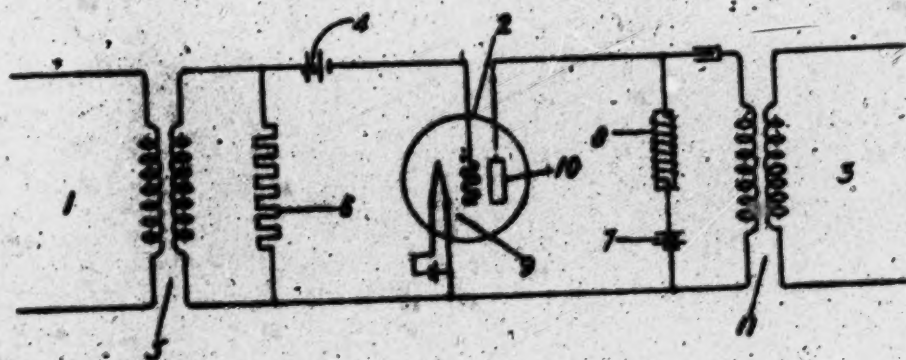
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Mar. 13, 1923.

H. D. ARNOLD.  
THERMIONIC AMPLIFIER CIRCUITS.  
FILED FEB. 3, 1919.

1,448,550



Inventor:  
Harold D. Arnold  
by *[Signature]* ATT



Patented Mar. 13, 1923.

1,448,550

## UNITED STATES PATENT OFFICE.

HAROLD B. ARNOLD, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## THERMIONIC AMPLIFIER CIRCUITS.

Application filed February 2, 1919. Serial No. 374,759.

To all whom it may concern:

Be it known that I, HAROLD B. ARNOLD, a citizen of the United States, residing at Maplewood, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Thermionic Amplifier Circuits, of which the following is a full, clear, concise, and exact description.

The invention relates to repeater circuits wherein an electron-discharge device is employed for receiving comparatively weak incoming impulses and for transmitting them in the same form or in a modified form but with amplified energy. Such an amplifier which has a cathode, an anode and a control member usually in the form of a grid electrode, has a very high impedance between control member and cathode which are the usual input electrodes. This impedance is of the order of 25,000 ohms or more being in the nature of a space discharge path between electrodes in a vacuum. Preferably, the vacuum is as perfect as practicable, substantially no positive ionization taking place during the operation of the device. In case a source of potential is employed for making the potential of the grid always negative, the input circuit impedance is of the order of infinity, for no electrons can flow from the filament to an electrode which is negative, so that no current flow takes place between cathode and grid even though the latter does respond to the incoming potential variations.

An object of the present invention is to modify the effect of this high input impedance so that it may have any desired finite value.

This is accomplished by connecting the incoming line to the repeater through a transformer, the secondary coil of which is shunted by a high impedance preferably a resistance of the order of 500,000 ohms, and may, for instance, range from approximately 100,000 ohms to 1,000,000 ohms. This resistance is also in shunt to the input electrodes. The impedance between the input electrodes may be made much higher than 500,000 ohms by a battery or other source which maintains the grid negative. The impedance of the secondary side of the transformer is practically that of the maximum ohm resistance, as the higher impedance path between the input electrodes takes

practically no current or at least a negligible current.

By this arrangement the same amplification can be secured with amplifier tubes having different input impedances, and it is possible to substitute one such tube for another in a given circuit arrangement.

More uniform amplification may also be secured by this arrangement with varying input power. In the use of amplifier circuits heretofore designed it has been found that there is a tendency for small input voltages to be amplified proportionately more than large input voltages, for the reason that the input impedance of the tube is greater for small voltages than for large voltages, especially when no means is employed for maintaining the control electrode negative with respect to the cathode. By the use of a shunt path of constant resistance less than that between the input electrodes this tendency is substantially eliminated.

Able from the above mentioned advantages of using the shunt impedance, it has the advantage, regardless of the function of the vacuum tube or of the circuit in which it is connected, of preventing singing of the repeater in case the output and input circuits thereof are coupled either designedly by an inductive coupling for instance, or accidentally by reason of the proximity of the input and output leads of the repeater.

A further advantage inherent in the use of a high impedance shunt between the line and the repeater is that it is possible to employ vacuum tubes having different but high impedances in the same circuit without substantially affecting the impedance of the circuit as seen from the primary side of the transformer.

This application is a continuation in part of application Serial No. 32,210, filed November 2, 1915, and of application Serial No. 38,872, filed September 3, 1918.

For further details of the invention, reference may be made to the drawings in which the single figure illustrates diagrammatically a repeater circuit embodying the invention.

Referring in detail to the figure, the incoming line 1 is adapted to be traversed by weak incoming impulses which are to be amplified by the amplifier 2, and to be sent out in amplified form upon the line 3. Pref-



ably, there is employed the battery 4 or other source which maintains the grid negative with respect to the cathode, in which case the input impedance of the repeater is practically infinite, as described above. The line 1 is connected to the input electrodes of the repeater which, in this case, are the grid and cathode electrodes, by the repeating coil or transformer 5. In shunt to the secondary of the repeating coil 5 and also in shunt to the input electrodes is the impedance 6, which may be non-inductive as shown and in the form of a resistance of the order of 500,000 ohms. This resistance may assume any desired form; viz., it may be a wire resistance, a lava resistance, or a piece of paper soaked with lactic acid and sealed in a glass tube. The battery 7 in the output circuit of the repeater supplies space current through the choke coil 8 and between cathode 9 and anode 10. If desired, the output circuit of the repeater may be coupled to the line 3 by the repeating coil 11, as shown.

What is claimed is:

1. The combination of a vacuum discharge repeater of the three-electrode type, an inductive coil conductively connected to the input electrodes of said repeater, and a conductive impedance in shunt to said coil.
2. The combination of an incoming line, an electric discharge repeater of the three-electrode type, a transformer coupling said line to said repeater, one end of said transformer being conductively connected to the input electrodes of said repeater, and a conductive impedance in shunt to one of the coils of said transformer.
3. The combination of an incoming line, an electric discharge repeater of the three-electrode type, a transformer coupling said line to said repeater, the secondary coil of said transformer being conductively connected to the input electrodes of said repeater, and a conductive impedance in shunt to said secondary coil.
4. The combination of a line, a vacuum tube amplifier of the three-electrode type connected thereto, said amplifier having in shunt thereto, means for applying a steady difference of potential between said input terminals, and a high resistance connected to said terminals.
5. The combination of a line, a vacuum tube amplifier connected thereto, said amplifier having grid and cathode electrodes, means for applying a steady difference of potential between said electrodes, and a resistance of the order of 500,000 ohms in shunt between said electrodes.
6. The combination of a vacuum tube amplifier having grid and cathode electrodes, means for making the potential of

said grid negative with respect to said cathode, and a high resistance by-path for said electrodes.

7. The combination of a line, a vacuum tube amplifier, a transformer for connecting said line to said amplifier, a by-path between said line and said amplifier and having an impedance of the order of 500,000 ohms, and means for maintaining the impedance of said amplifier greater than that of said by-path.

8. The combination of an incoming line, a repeater having a cathode and an anode, means for supplying a space current between said electrodes, a resistor for controlling said space current, means for applying a steady difference of potential between said cathode and said control resistor and means between said line and said repeater for making the impedance of the repeater as seen from said line, substantially of a constant value.

9. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a space current between said electrodes, a grid electrode for controlling said space current, means for making said grid negative with respect to said cathode, and means between said line and the input electrodes for making the impedance of said amplifier as seen from said line, substantially of a constant value.

10. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a space current between said electrodes, a grid electrode for controlling said space current, means for making said grid negative with respect to said cathode, a transformer for connecting said line to said amplifier, and a high resistance in shunt to the secondary winding of said transformer and to said grid and cathode electrodes for making the impedance of said amplifier as seen from said line, substantially of a constant value.

11. The combination of a line, an amplifier in circuit therewith having an input impedance at least as high as 100,000 ohms, and a shunt between said line and said amplifier having an impedance of an order lower than that of the input impedance of said amplifier.

12. The combination of a line, an amplifier in circuit therewith having an input impedance which is practically infinite, and a shunt between said line and said amplifier having an impedance of the order of 500,000 ohms.

In witness whereof, I have hereunto subscribed my name this 14th day of January, A. D. 1926.

HAROLD B. ARDOLD.



PLAINTIFF S' EXHIBIT No. 1 G

643

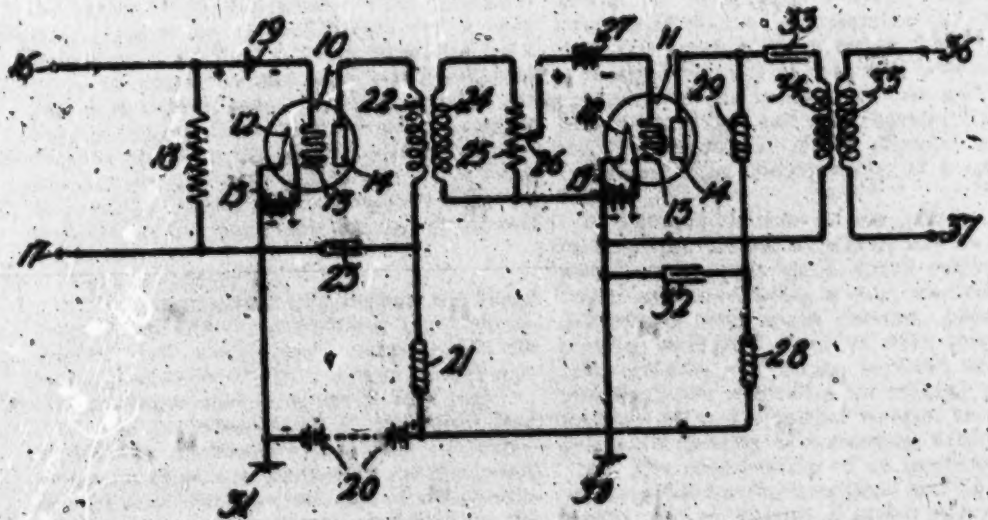
Aug. 21, 1923.

1,465,332

H. DE F. ARNOLD

VACUUM TUBE AMPLIFIER

Original Filed Sept. 3, 1915



Inventor:  
Harold D. Arnold.  
By W. E. Smith, Atty



Patented Aug. 21, 1923.

1,465,332

## UNITED STATES PATENT OFFICE.

HAROLD DE FOREST ARNOLD, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## VACUUM-TUBE AMPLIFIER.

Original application filed September 3, 1915, Serial No. 65,573. Divided and application filed March 22, 1922, Serial No. 225,557. Divided and this application filed August 24, 1922. Serial No. 654,325.

To all whom it may concern:

Be it known that I, HAROLD D. ARNOLD, a citizen of the United States, residing at Maplewood, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Vacuum-Tube Amplifiers, of which the following is a full, clear, concise, and exact description.

This invention relates to vacuum tube amplifiers, and more particularly to arrangements for supplying space current thereto.

An object of this invention is to provide means whereby a plurality of vacuum tubes to be used as repeaters or amplifiers may be supplied with space current from a single source, but in such a manner that current changes in one tube due to signals being repeated cannot be impressed upon another tube through said source.

With the arrangement shown herein, a single source of space current is used to energize both tubes of a two stage amplifier, and in the branches of the circuit therefore are interposed filters of series inductance and shunt capacity to prevent alternating current from being bypassed therethrough.

The invention described and claimed herein is divided out of my applications, Serial No. 65,573, filed September 3, 1915, and Serial No. 225,557, filed March 22, 1922.

For further details, reference may be made to the accompanying drawings in which the single figure illustrates diagrammatically a two stage amplifier embodying the invention.

Referring to the drawing by reference numerals, the amplifier set comprises a tandem arrangement of two vacuum tubes 10 and 11 each having cathode 12, a grid or control electrode 13, and an anode 14. The cathodes 12 are maintained in a condition of thermionic activity by currents from source 15.

The input circuit of tube 10 comprises terminals 16, 17, adapted to be connected to a suitable source of electric impulses to be repeated, a resistance 18 bridged across the input electrodes, and a battery 19 adapted to maintain the grid electrode at a negative potential with respect to the cathode. Current between the anode and cathode is supplied from battery or other suitable source 20, the current passing in series through the inductance 21 and the transformer primary

22. A shunt condenser 23 provides a path for the alternating current.

The transformer secondary 24 has connected across its terminals a resistance 25, one end of which is connected to the cathode of tube 11. A connection from resistance 25 to the grid of tube 11 comprises the movable contact 26 and the battery 27, the function of the latter being to provide the necessary negative potential on the grid.

Direct current is supplied to the tube 11 from source 28, through inductances 29 and 30, and grounds 30 and 31. Condenser 32 is shunted across the direct current circuit. The output circuit for alternating current comprises the condenser 33 and the primary 34 of a transformer, the secondary 35 of which is adapted to be connected through terminals 36 and 37 to any suitable receiving circuit.

In operation, the signals or other impulses, which are repeated and amplified by the tube 10, are impressed on the resistance 25 by currents induced in the secondary coil 24. The input electrodes of the second tube are shunt to an adjustable part of the resistance 25, and therefore any desired proportionate part of the potential drop across the resistance may be impressed between the input electrodes, with the result that the ratio of amplification may be varied between a predetermined maximum and zero.

The series inductances 21 and 28 and the shunt condensers 23 and 32 serve to prevent potential variations from the source or from either tube without being impressed through the supply circuit on the other tube.

While I have shown and described one embodiment of the invention, it is obvious that it may assume any desired form within the scope of the appended claims.

What is claimed is:

1. In combination, a plurality of vacuum tube repeaters, a common source of space current for said repeaters, the circuit between one of said repeaters and said source comprising series inductance, and a path comprising capacity bridged across said circuit between said source and said repeater.

2. In combination, a plurality of vacuum tube repeaters, a common source of space current for said repeaters, the circuit be-



tween each of said repeaters and said source comprising series inductance, and a path comprising capacity bridged across each of said circuits between said source and the respective repeaters.

3. In combination, a plurality of vacuum tube repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from one of said repeaters from flowing in the portion of the space current circuit common to said repeaters.

4. In combination, a plurality of vacuum tube repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from flowing from each said repeaters to the others of said repeaters through the portion of the space current circuit common to all.

5. In a multi-stage amplifier, a plurality of vacuum tubes connected in tandem, a common source of space current for said tubes, branch circuits connecting said source and said tubes, and a filter comprising series inductance in one of said circuits and a path containing capacity bridged across the circuit between one of said tubes and said source.

6. In a multi-stage amplifier, a plurality of vacuum tubes connected in tandem, a common source of space current for said tubes, branch circuits connecting said source and said tubes and a filter comprising series inductance in each of said circuits and a path containing capacity bridged across each of said circuits between each of said tubes and said source.

7. In combination, a plurality of vacuum tube translating devices, a common source of potential for said vacuum tubes, a circuit

connecting each of said tubes to said source containing series inductance, and a path comprising capacity bridged across each of said circuits.

8. In combination, a plurality of vacuum tube translating devices, a common source of current for energizing said tubes, and a path comprising capacity bridged across each of the circuits connecting said tubes to said source.

9. In combination, a plurality of vacuum tube translating devices, a common source of current for energizing said vacuum tubes, each of the circuits between said tubes and said source comprising series impedance, and a capacity effectively in shunt to said source for preventing interference between said tubes.

10. The combination is an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers in succession from the last to the first of said amplifiers, and filter connections between successive amplifiers of the series.

11. The combination is an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers, and filter connections between successive amplifiers of the series.

In witness whereof, I hereunto subscribe my name this 25th day of August A. D. 1920.

HAROLD DE FOREST ARNOLD.

PLAINTIFF'S EXHIBIT No. 1 H



646

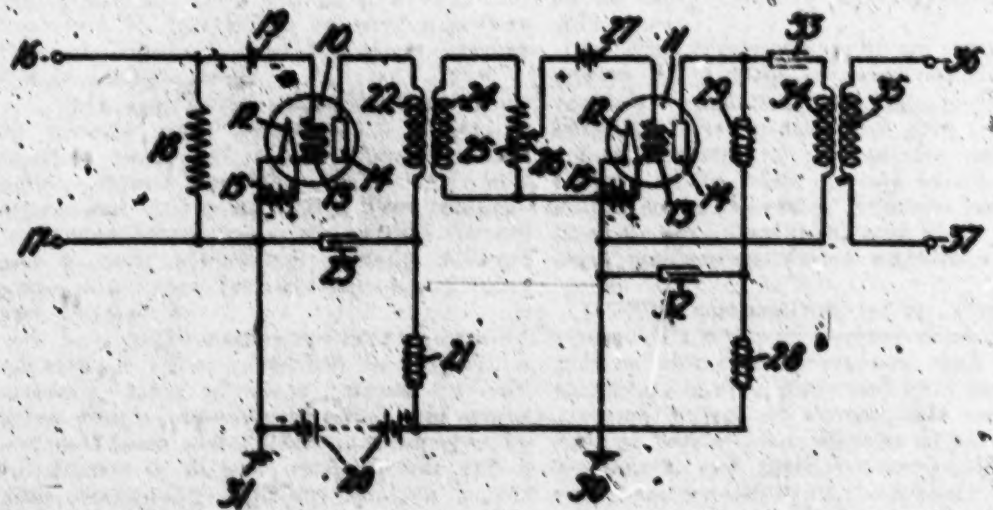
Dec. 30, 1924.

1,520,994

H. D. ARNOLD

ELECTRON DISCHARGE AMPLIFIER

Original Filed Sept. 3, 1915



Inventor:  
Harold D. Arnold  
by J. P. Smith A. H. Y.

Patented Dec. 30, 1934.

1,524,994

## UNITED STATES PATENT OFFICE.

HAROLD D. ARNOTT, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ELECTRON-DISCHARGE AMPLIFIER.

Original application filed September 2, 1932, Serial No. 68,579. Divided and this application filed March 29, 1934. Serial No. 342,327.

To all whom it may concern:

Be it known that I, HAROLD D. ARNOTT, a citizen of the United States, residing at Maplewood, in the county of Essex, State of New Jersey, have invented certain new and useful improvements in Electron-Discharge Amplifiers, of which the following is a full, clear, concise, and exact description.

This invention relates to electron discharge devices, and more particularly to an arrangement for and method of varying the ratio of amplification of an electron discharge amplifier.

It is an object of the invention to provide means whereby the ratio of amplification can be varied without varying the impedance presented by the amplifier as a whole to the impulses which are to be amplified.

This is accomplished in the preferred form of the invention by the use of an impedance-shunted across the terminals of the secondary of a transformer and by step up the voltage of the incoming currents. The cathode of an electron discharge tube of the three-electrode type is connected to one end of this impedance, and a connection is made from the control electrode by means of an adjustable contact to a desired point on the impedance, thus varying the proportionate part of the potential drop across the impedance which is applied between the control electrode and the cathode, and correspondingly varying the amplification in the output circuit of the tube.

A specific feature of my invention is the incorporation of the above described controlling arrangement in the output-input coupling between two stages of a multi-stage amplifier. With this arrangement, a single source of space current is used to energize both tubes, and in the branches of the circuit therefor are interposed filters of series inductances and shunt capacity to prevent alternating current from being bypassed therethrough.

The invention described and claimed herein is divided out of my application Serial No. 68,579, filed September 2, 1932, issued as Patent No. 1,468,350, August 12, 1923. The invention claimed herein is related to the invention claimed in my pending application Serial No. 374,720, filed February 2, 1932,

issued as Patent No. 1,468,350, March 12, 1923.

For further details, reference may be made to the accompanying drawings in which the single figure illustrates diagrammatically a two stage amplifier embodying the invention.

Referring to the drawing by reference numerals, the amplifier set comprises a tandem arrangement of two vacuum tubes 10 and 11 each having a cathode 12, a grid or control electrode 13, and an anode 14. The cathodes 12 are maintained in a condition of thermionic activity by currents from source 15.

The input circuit of tube 10 comprises terminals 16, 17, adapted to be connected to a suitable source of electric impulses to be repeated, a resistance 18 bridged across the input electrodes, and a battery 19 adapted to maintain the grid electrode at a negative potential with respect to the cathode. Current between the anode and cathode is supplied from battery or other suitable source 20, the current passing in series through the inductances 21 and the transformer primary 22. A shunt condenser 23 provides a path for the alternating current.

The transformer secondary 24 has connected across its terminals a resistance 25, one end of which is connected to the cathode of tube 11. A connection from resistance 25 to the grid of tube 11 comprises the movable contact 26 and the battery 27, the function of the latter being to provide the necessary negative potential on the grid.

Direct current is supplied to the tube 11 from source 20, through inductances 28 and 29, and grounds 30 and 31. Condenser 32 is shunted across the direct current circuit. The output circuit for alternating current comprises the condenser 33 and the primary 34 of a transformer, the secondary of which is adapted to be connected through terminals 35 and 37 to any suitable receiving circuit.

In operation, the signals or other impulses, which are repeated and amplified by the tube 10, are impressed on the resistance 18 by currents induced in the secondary coil 24. The input electrodes of the second tube are in shunt to an adjustable part of the resistance 25, and therefore any desired proportionate part of the potential



drop across the resistance may be impressed between the input electrodes, with the result that the ratio of amplification may be varied between a predetermined maximum and zero.

Since the grid is at a negative potential with respect to the cathode, no current can flow therebetween, and since the capacity of these electrodes is negligibly small, the impedance of the tube to the signals is substantially infinite. It is thus seen that at all positions of the contact 25 the impedance of the second amplifying unit to the incoming impulse has substantially a constant value, namely, that of the fixed resistance 25.

While I have shown and described one embodiment of the invention, it is obvious that it may assume any desired form within the scope of the appended claims. For example, the first amplifying unit with its output transformer might be replaced by any suitable circuit adapted to have electric currents produced therein. Other modifications will occur to anyone skilled in the art.

What is claimed is:

1. In combination, an electron discharge relay comprising an anode, a cathode and a control electrode, a circuit containing a source of alternating current electric impulse to be relayed, an impedance in series to said source, and means comprising a contact movable along said impedance for effectively connecting said control electrode and said cathode across an adjustable proportion of the whole of said impedance.

2. In combination, a vacuum tube repeater, an input transformer, an impedance connected across the terminals of the transformer secondary, a connection from said impedance to an electrode of said vacuum tube, and a connection from a point intermediate the ends of said impedance to another electrode of said vacuum tube.

3. In combination, an electron discharge relay having an anode, a cathode and a control electrode, a circuit containing an impedance means for producing alternating voltage across the whole of said impedance, and means comprising a contact movable along said impedance for effectively connecting said cathode and control electrode across an adjustable proportion of the whole of said impedance.

4. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a signal current between said electrodes, said amplifier having a grid electrode for controlling said signal current, means for making said grid negative with respect to said cathode, and means between said line and the input electrodes for making the impedance of said amplifier as seen from said line substantially of a constant

value, said last mentioned means comprising a potentiometer arrangement including an impedance and a contact movable along said impedance for varying the voltage supplied to said input electrodes.

5. A vacuum tube repeater comprising a vacuum tube having input electrodes, an input transformer, a resistance bridged across the secondary of said transformer, a connection from one of said electrodes to said resistance, and an adjustable connection from the other of said electrodes to a point on said resistance.

6. In combination, a vacuum tube having input and output electrodes, an electric circuit including a resistance connected to one of said input electrodes, a connection from an adjustable contact on said resistance to the other of said input electrodes, means for producing an alternating current through the whole of said resistance, and means connected to said output electrodes for transmitting an amplified current of substantially the same wave form as said first mentioned current.

7. In a multi-stage amplifier, two amplifying stages each including an electron discharge amplifier, a coupling between said stages comprising a resistance effectively in the output circuit of one amplifying unit, a connection from said resistance to an electrode of the succeeding amplifying unit, and a contact movable along said resistance and connected to another electrode of said succeeding amplifying unit.

8. In a multi-stage vacuum tube amplifier, two vacuum tubes each having a cathode, an anode and a control electrode, a circuit containing a resistance effectively connected to the cathode and anode of one of said tubes, a connection from said circuit to the cathode of the other of said tubes, and a contact movable along said resistance and connected to the control electrode of said last mentioned tube.

9. In a multi-stage vacuum tube amplifier, two vacuum tubes each having input and output electrodes and a coupling therebetween comprising a transformer having its primary connected to the output electrodes of one of said tubes, a resistance connected across the secondary of said transformer, a connection from said resistance to an input electrode of the other of said tubes, and a connection from an adjustable point on said resistance to the other input electrode of said last mentioned tube.

10. In a multi-stage vacuum tube amplifier, a vacuum tube, a resistance, means for applying voltage in the output voltage of said vacuum tube across said resistance, a second vacuum tube, and means for applying a selected part of the drop in potential across said resistance to said second vacuum tube.



11. The method of operating a vacuum tube amplifier which comprises supplying alternating current to be amplified, and varying the ratio of amplification while the impedance opposed to said alternating current remains substantially constant.

12. The method of operating an electron discharge amplifier having input electrodes which comprises supplying alternating current to be amplified, maintaining the impedance opposed to said alternating current substantially constant and varying the ratio of amplification by applying a selected part of the potential of said alternating current to said input electrodes.

13. The method of operating a vacuum tube amplifier, which comprises supplying alternating current to be amplified, varying the ratio of amplification while maintaining the impedance opposed to said alternating current substantially constant and transmitting a current through the output circuit having substantially the same wave form as that of the incoming current.

14. The method of operating a vacuum tube amplifier having input electrodes which comprises supplying alternating current to be amplified, changing the potential of said current at a fixed ratio of transformation, and applying a selected proportionate part of the potential of the transformed current to said input electrodes.

15. The combination of an incoming line, an electron discharge relay of the three-electrode type, a transformer coupling said line to said relay, one coil of said transformer being inductively connected to the input electrodes of said relay, and a potentiometer arrangement in shunt to one of the coils of said transformer, said potentiometer arrangement comprising an impedance and a contact movable along said impedance for varying the voltage applied to said input electrodes without materially varying the impedance facing said line.

In witness whereof, I hereunto subscribe my name this 20th day of March, A. D. 1919.  
HAROLD D. ARNOLD.

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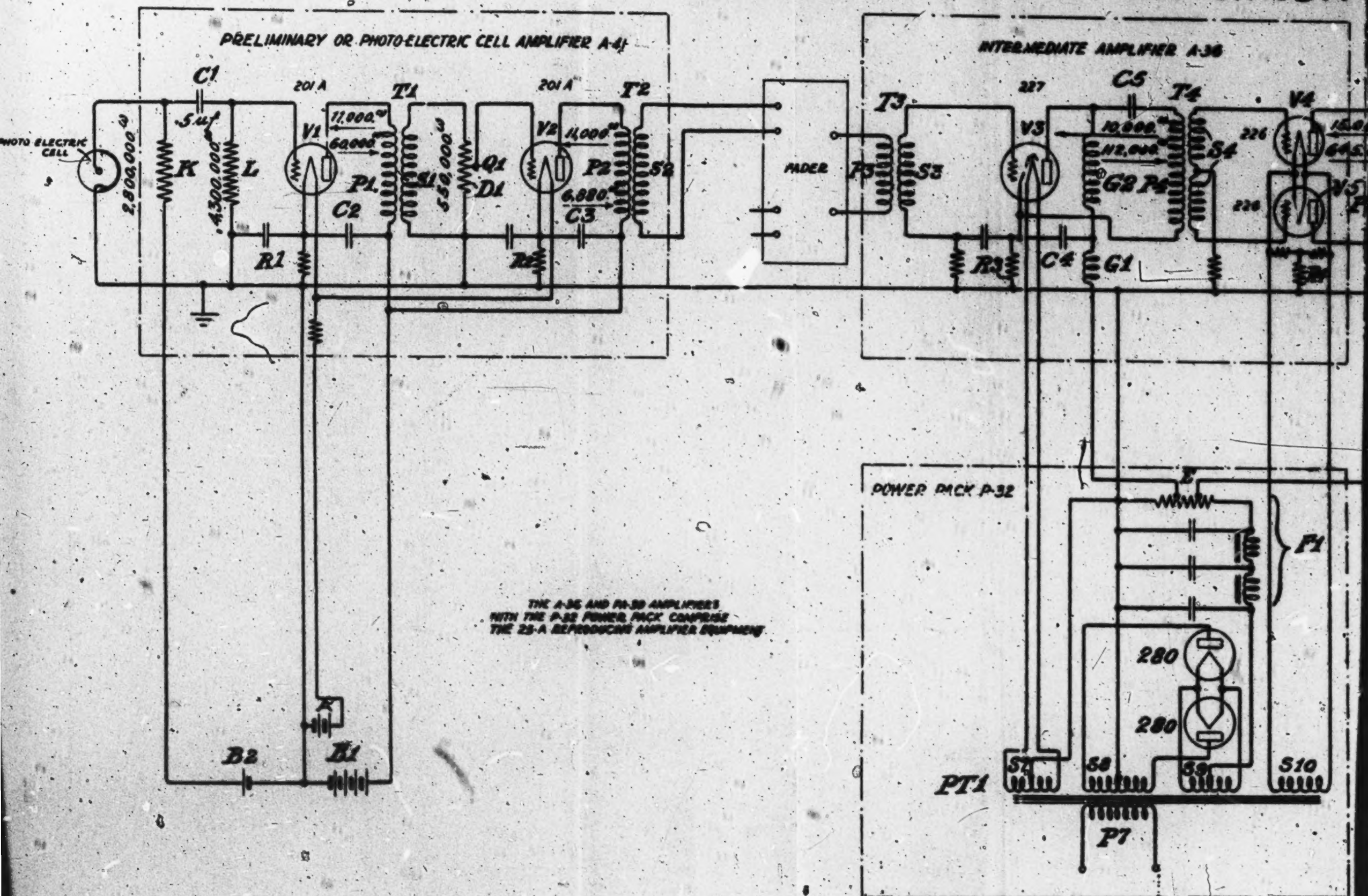
**Patents in Suit and Claims Relied Upon As To Each Part Of Defendant's Apparatus**

650

Suit No.	Patent No.	Patentee	Descriptive Title Of Invention	Issue Date	Claims Relied Upon As To Each Part Of Defendant's Apparatus	Item No.
50-177	1,231,764	Lowenstein	Negative Grid Bias Patent	July 3, 1917	1, 2, 4, 5, 6, and 7 as to A-41, A-36 and PA-39	1
50-177	1,426,784	Methes	Grid Biasing Resistance Patent	Aug. 22, 1922	8 as to A-41	2
50-175	1,309,283	Arnold	Power Circuit Patent	Jan. 27, 1920	7, 10 and 13 as to PA-39	3
50-175	1,349,252	Arnold	Straight Line Characteristic Patent	Aug. 10, 1920	15 as to A-41, A-36 and PA-39	4
50-178	1,403,475	Arnold	Resistance-Capacity Coupling Patent	Jan. 17, 1922	6, 9, and 10 as to A-41	5
50-175	1,448,550	Arnold	Definite Input Impedance Patent	Mar. 13, 1923	1 and 12 as to A-41	6
50-178	1,485,332	Arnold	Common Plate Supply Patent	Aug. 21, 1923	3, 8, 10 and 11 as to A-41, and 1, 3, 5, 10 and 11 as to A-36 and P-32 Power Pack	7
50-175	1,520,994	Arnold	Gain Control Patent	Dec. 30, 1924	1 and 4 as to A-41	8



### DEFENDANT'S AMPLIFIER CIRCUIT

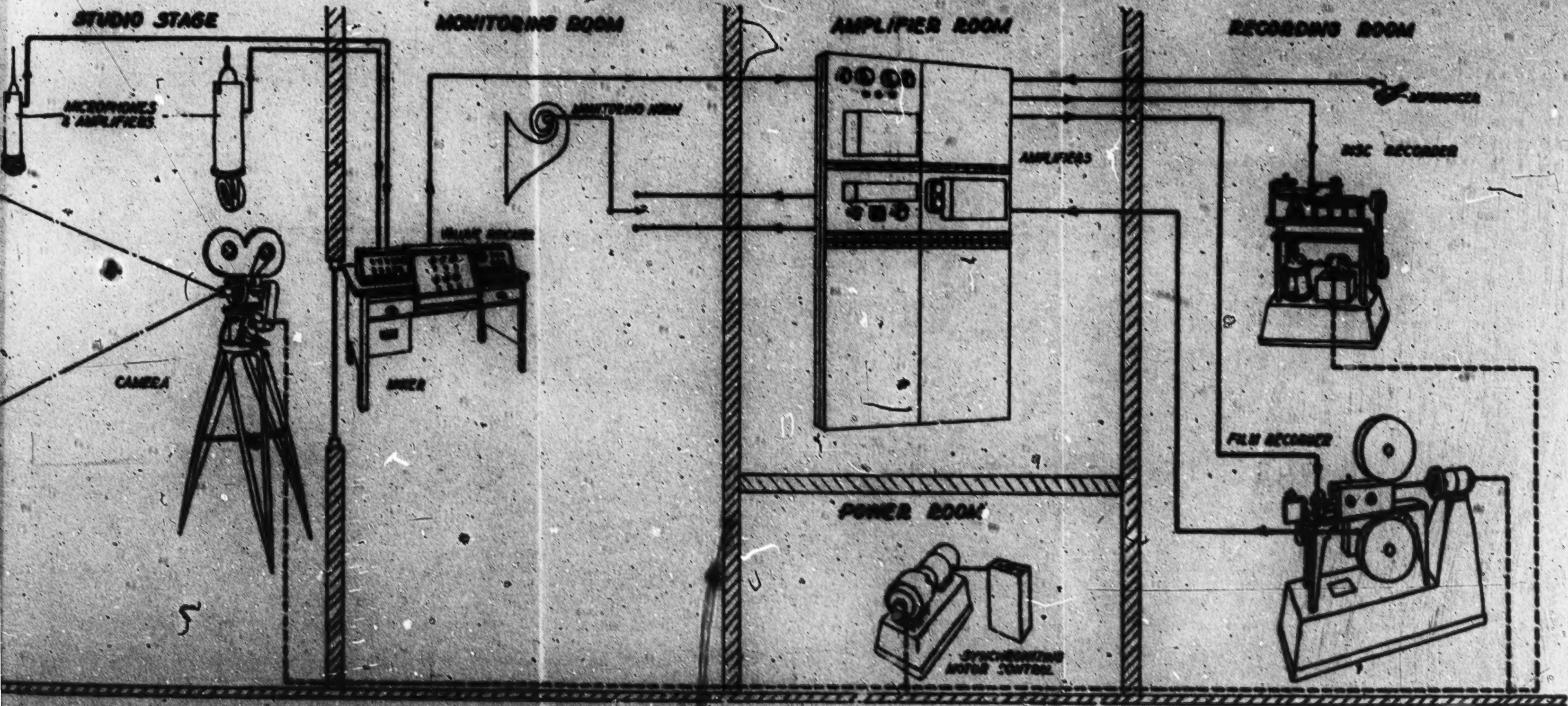






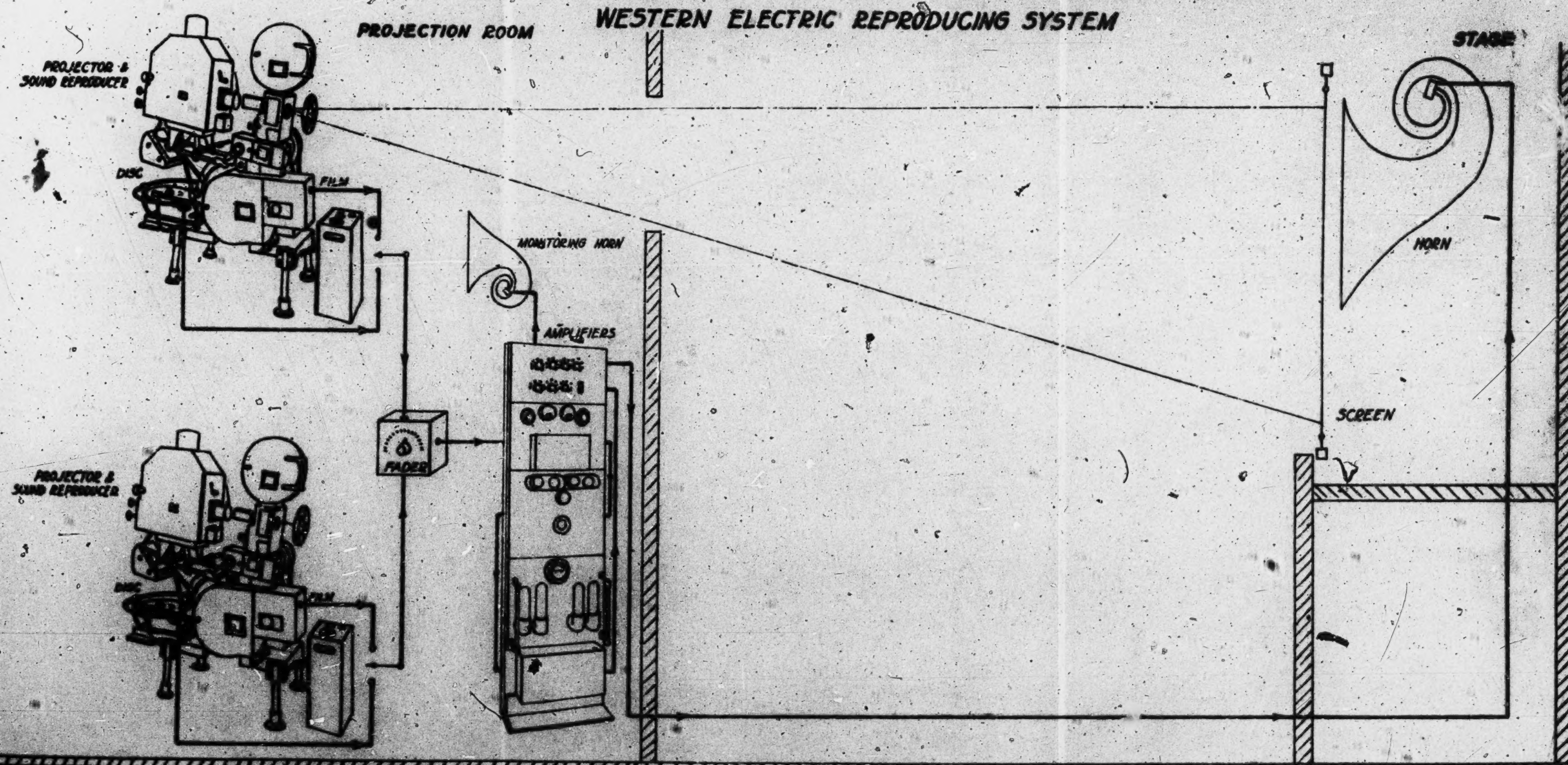


# WESTERN ELECTRIC RECORDING SYSTEM





PLAINTIFF'S EXHIBIT No. 4  
Reproducing  
Diagram of the Western Electric Recording System





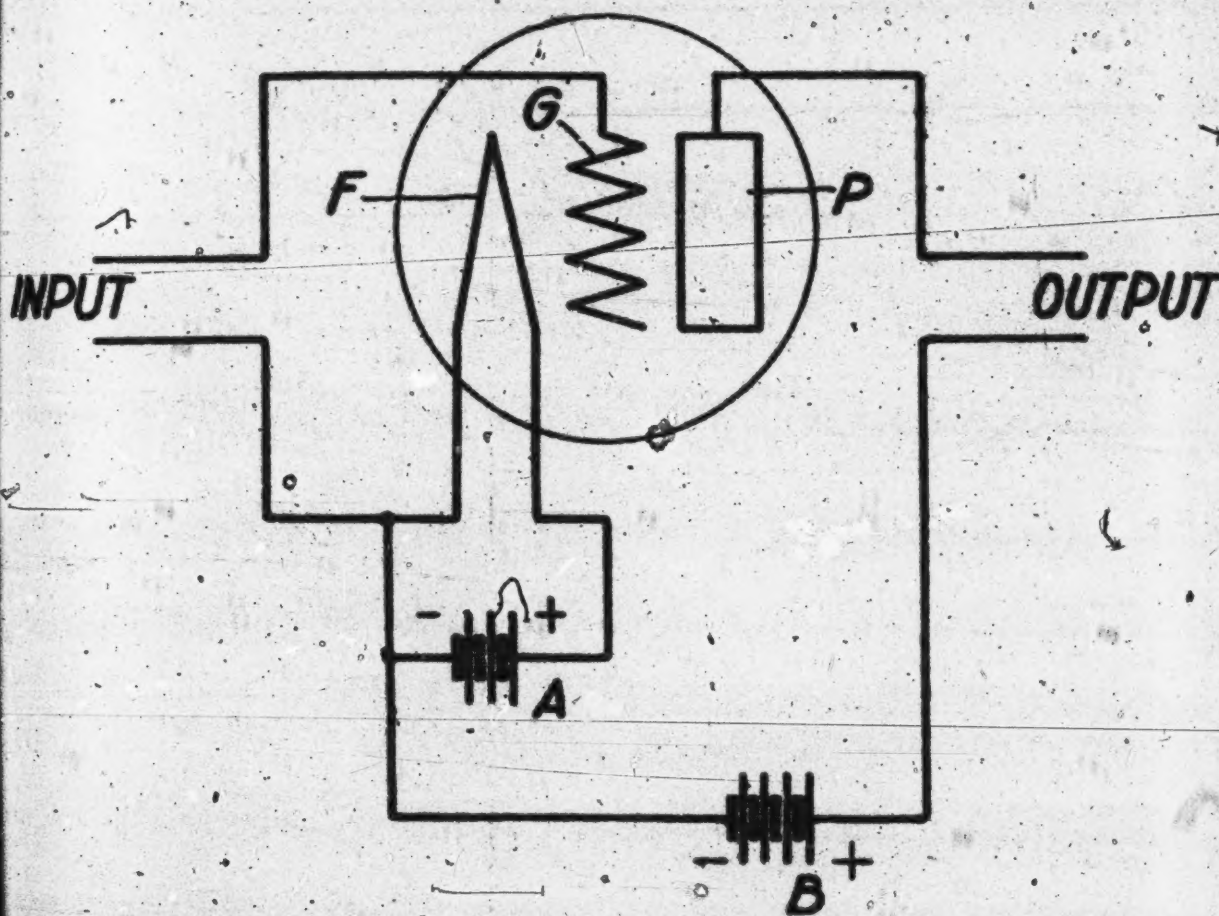
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## PLAINTIFF/S' EXHIBIT No. 5

Diagram illustrating the three-electrode vacuum tube and circuits

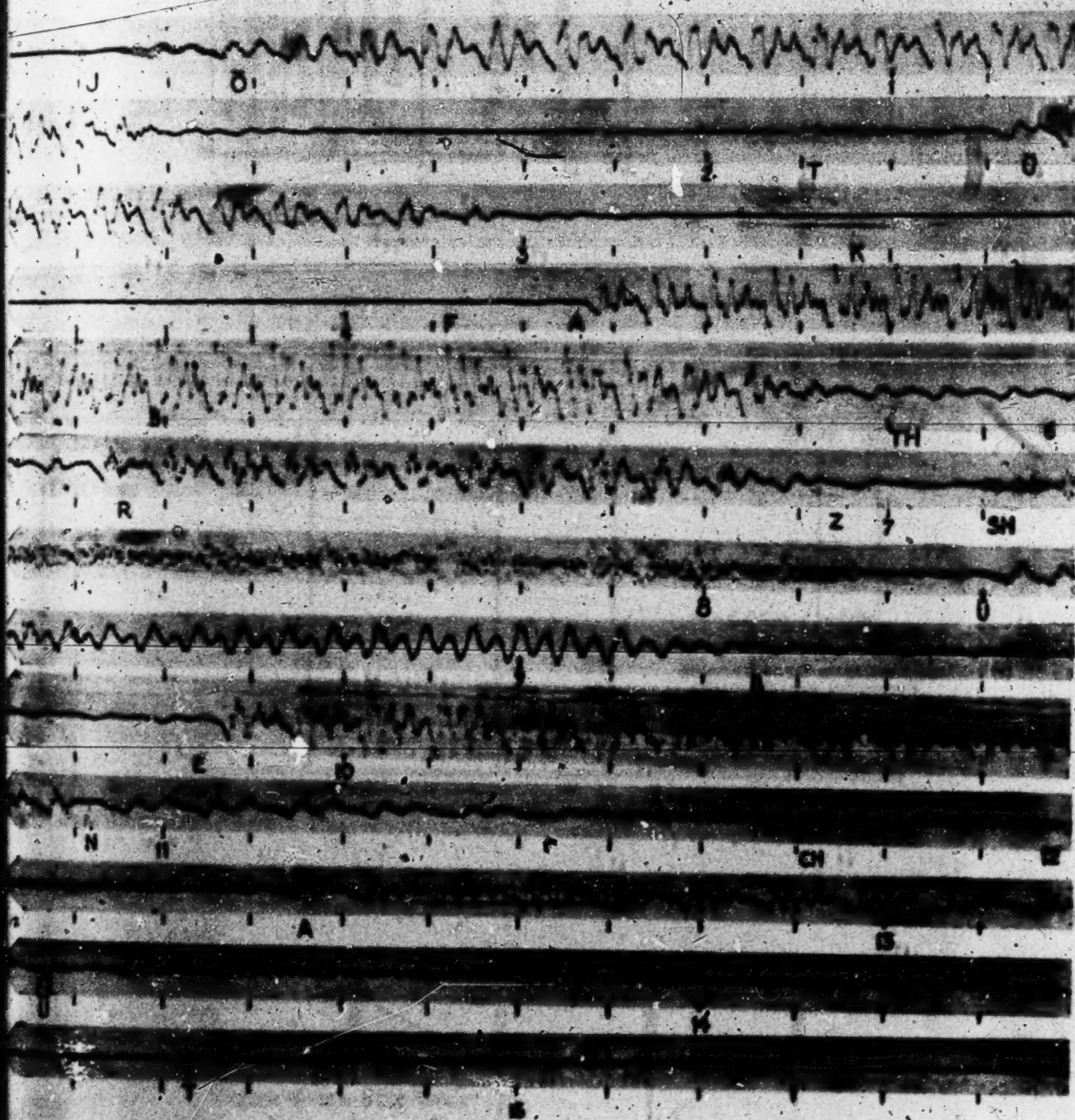


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PLAINTIFF S' EXHIBIT No. 6  
 Oscillograms of voice currents



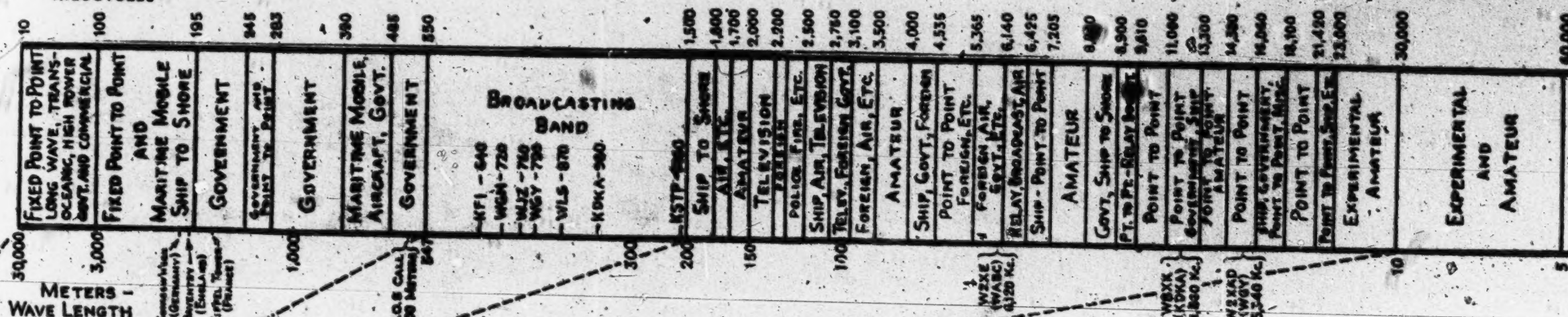
PHOTOGRAPH OF OSCILLOGRAM:  
 "JOE TOOK FATHER'S SHOE BENCH OUT"  
 TIME INTERVALS NUMBERED FOR EACH TENTH SECOND  
 AND SUBDIVIDED FOR EACH ONE-HUNDREDTH SECOND

+5682



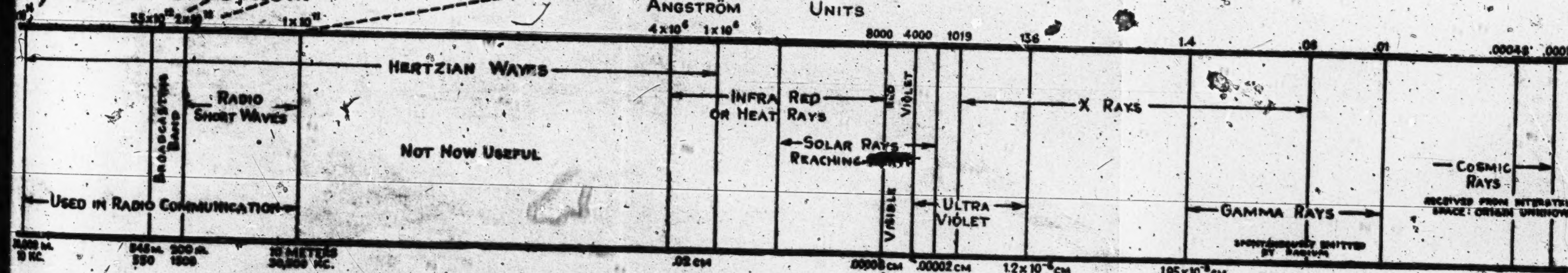
# THE RADIO SPECTRUM

KILOCYCLES

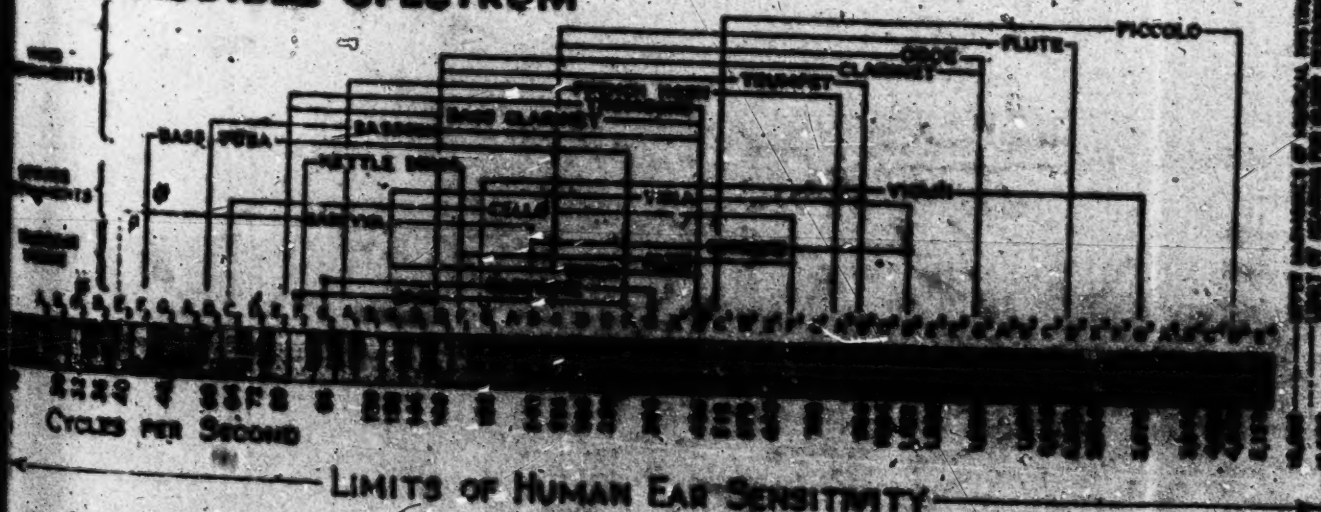


# THE ETHER SPECTRUM

ÅNGSTRÖM                      UNITS

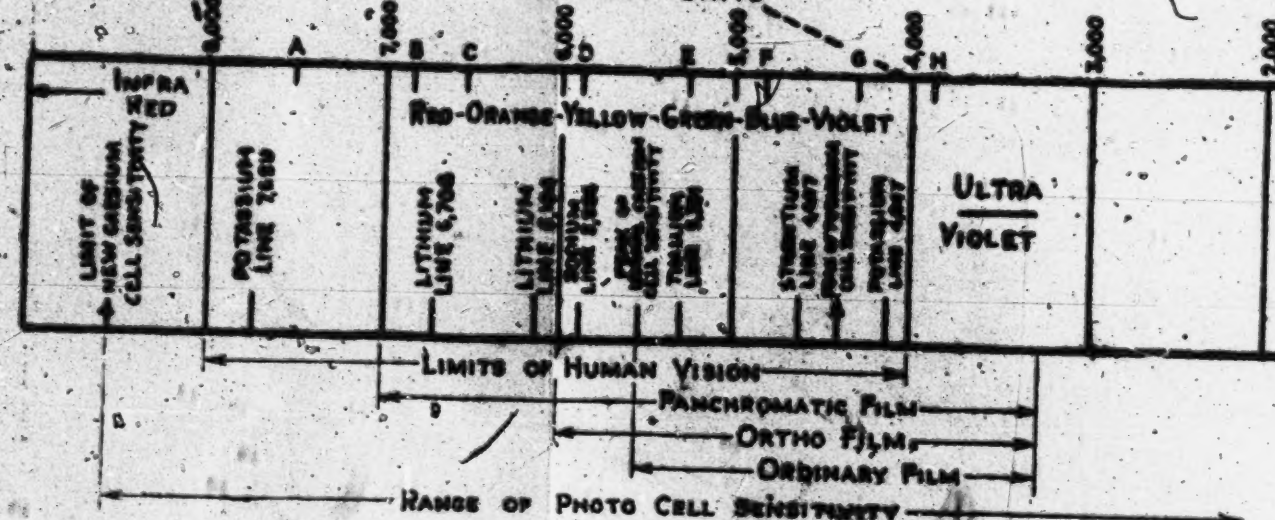


# THE AUDIBLE SPECTRUM



# THE PHOTO-ELECTRIC SPECTRUM

ANGSTRÖM UNITE





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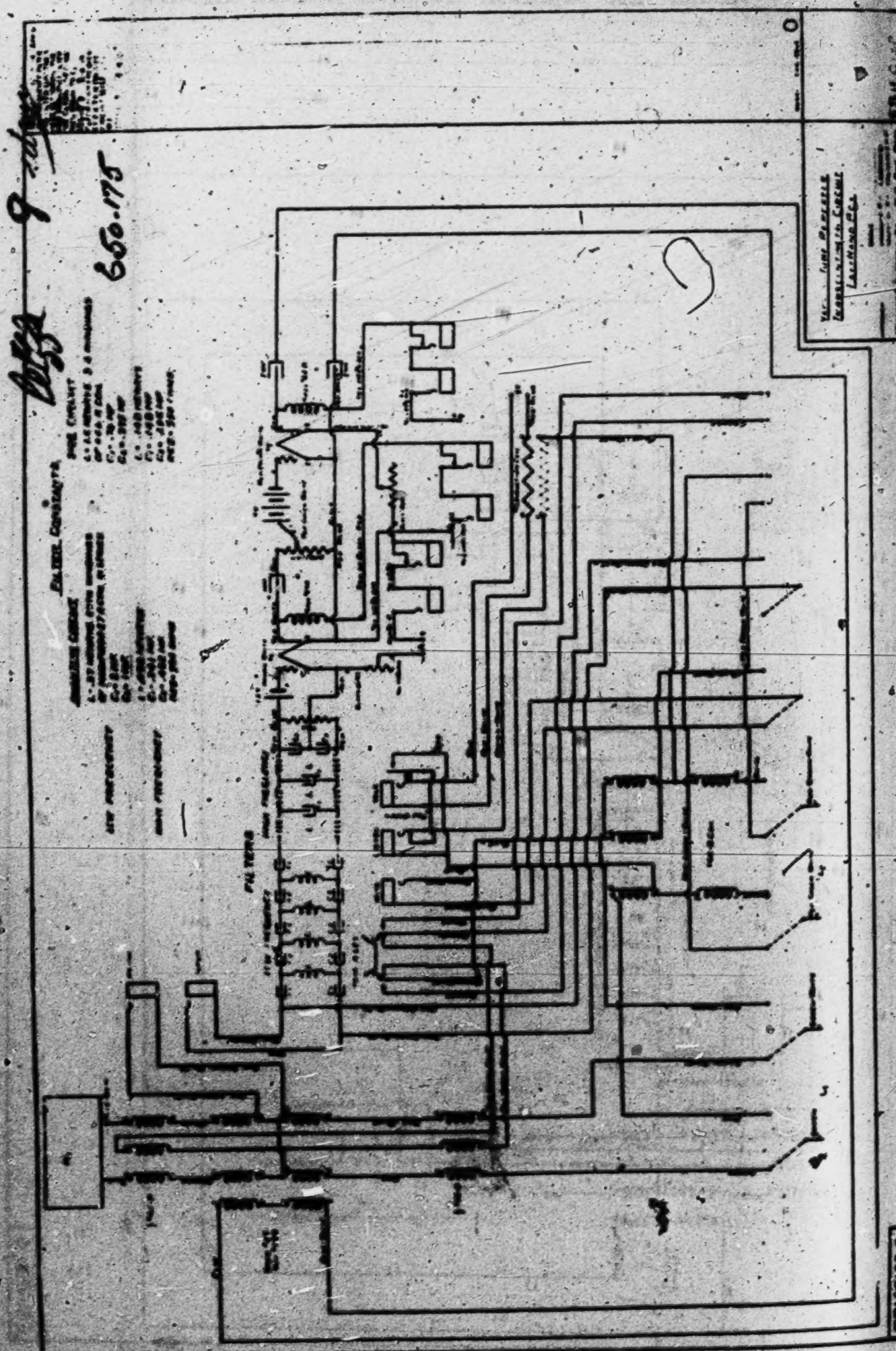
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**PLAINTIFF S' EXHIBIT No. 9**

Tracing ES160,132 dated December 8, 1914, entitled "Vacuum Tube Repeater Transcontinental Circuit"



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**PAGE**



SAN FRANCISCO CHRONICLE  
JAN. 25, 1915

# INVENTOR CELEBRATES TRIUMPH

Mayor Rolph of San Francisco and Mayor Mitchell of New York in Chat.

Officially and formally, San Francisco telephoned to New York today.

History was made when Mayor Rolph, sitting at a decorated table in the city hall in the office of the Pacific Telephone and Telegraph Company on Grant avenue and Broadway put the receiver of an extraordinary dash instrument to his ear and shouted with Mayor John P. Mitchell of New York that they were talking across the bay to cities of across the continent.

Later this afternoon it is planned to record the conversation in Boston. The telephone to this continent has been made.

It was a triumph of what this city has done. By the Pacific Telephone and Telegraph Company, which has been making the telephone to this continent.

The event was celebrated with a large crowd of people in the city hall. The telephone to this continent has been made.

The telephone to this continent has been made.

New York, and as one of the workers put it, "one foot of wire down knocks the whole system, and where's our ceremony then?"

## INVENTOR CHAIR

To New York, apparently, the new connection meant as much as it did to San Francisco. The celebration in business circles both ways. Today's ceremony was conducted officially from the New York office at 20 Wall street. The leaders did not leave their offices because in advance and the celebration was a series of wireless conversations from the West.

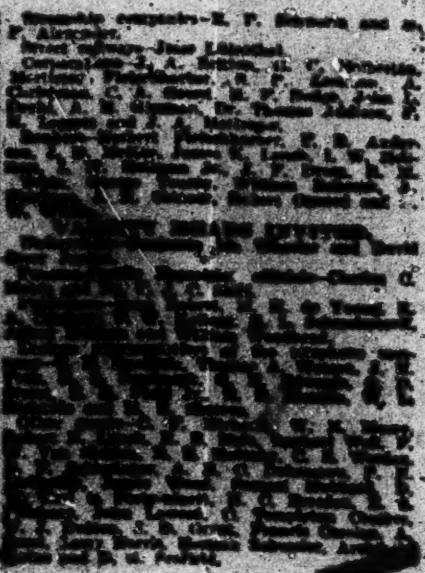
Perhaps the most interesting feature was the conversation between Alexander Graham Bell, the venerable inventor of the telephone, who was at the New York end, and Thomas A. Watson, who was his assistant and partner in 1876, when the invention was made. Watson is now retired, having assumed a fortune at his invention. He was sent out here by the Bell company to be a member of the celebration.

When the first message was sent over the telephone, which was called from the room in the city hall, the words were "Mr. Watson, please come here. I want you." The words were sent from the New York office to the San Francisco office.

The telephone to this continent has been made.

The telephone to this continent has been made.

INFORMATION DEPT  
OFFICE COPY



## NEW YORK TIMES JANUARY 26, 1915.

### PHONE TO PACIFIC FROM THE ATLANTIC

Perfect Test of Transcontinental Line Made by Inventors Bell and Watson.

### 4,760-MILE RECORD SET

President Wilson, Mayor Mitchell, and Other Noted Men Participate in Celebration.

On Oct. 3, 1876, Alexander Graham Bell and Thomas A. Watson talked by telephone to each other over a two-mile wire stretched between Cambridge and Boston. It was the first wire conversation ever held. Yesterday afternoon the same two men talked by telephone to each other over a 4,760-mile wire between New York and San Francisco. Dr. Bell, the veteran inventor of the telephone, was in New York, and Mr. Watson, his former assistant, was on the other side of the continent. They talked and other men with them. This day did in fact what the telephone has done for the world.

The celebration of the first transcontinental telephone call was observed yesterday afternoon and last night in New York, San Francisco, Washington, Boston, and other cities. The telephone to this continent has been made.

The telephone to this continent has been made.

The telephone to this continent has been made.

Articles from the San Francisco Bulletin of January 15, 1915, the New York Times of January 26, 1915, the San Francisco Chronicle, January 27, 1915, and the Morning Tribune of January 26, 1915, relating to the opening of the Transcontinental Line

U. S. Marshall, master who presided of the American Telephone and Telegraph company, presided at the celebration. Before the transcontinental message, which was made a short time ago, the telephone to this continent has been made.

First Voice Across Continent. And Mr. Watson replied that he was and that he heard distinctly. This was the first human voice heard across the continent. The hundreds at both ends of the line broke into enthusiastic applause.

After talking for a minute or two through a modern instrument, Dr. Bell picked up an exact duplicate of the telephone made for him by Mr. Watson in 1876, the original of which is in the Smithsonian Institution in Washington. This was connected with the San Francisco wire and Dr. Bell spoke through it.

"Hello, Mr. Watson," he said. "Can you hear me?"

"I hear you perfectly," Mr. Watson replied.

A second message was sent from New York to San Francisco. The telephone to this continent has been made.

The telephone to this continent has been made.

President Wilson, who stands at the gateway of the West. It is a long way to San Francisco, but I think that by the opening of the transcontinental telephone line, the distance is no longer so great.

After the celebration, the telephone to this continent has been made.

The telephone to this continent has been made.

The telephone to this continent has been made.

The telephone to this continent has been made.

The telephone to this continent has been made.

The telephone to this continent has been made.



**Inventor and Builder of First Telephone  
Inaugurate Service Between Eastern  
and Western Metropolises**

1876	Boston to Cambridge	3
1882	Boston to Providence	45
1884	New York to Boston	22
1882	New York to Chicago	90
1871	New York to Denver	210
1873	New York to San Francisco	1,100

Mayer James Hulse Jr. met a one  
and of a telephone wire yesterday  
and Mayer John Harvey Mitchell sat  
at the table and. Mayer Hulse was  
in San Francisco. Mayer Mitchell  
was in New York. They exchanged  
greetings, and their voices were not  
heard above the piano used in or-  
chestra accompaniment.

The talk of the two mayors oc-

electrical waves, swept across the continent at a velocity of 56,000 miles a second, without tumbling over upon other or crossing each other's path, passed through noisy cities, crossed roaring rivers and snow-capped mountains, with their rate of speed faithfully preserved and conserved until, converted back into sound waves, they agitated the air in San Francisco precisely as they had done in New York.

"Ahoj! Ahoj! can you hear me?" said Dr. Bell in New York.  
 "I can hear perfectly" answered Mr. Watson.

When the telephone had grown so that it could be taken outdoors on October 9, 1974, Dr. Hall had called "Ahoy" across two miles of wire, just as he was calling "hey" forty years later, across three thousand four hundred miles.

And so completely has the telephone abolished space that it is more than one-tenth of a second, in Bell's ear, to reach the earth, although it is long from point to point it had passed through space.

coiled and strung in the Boston attic, were installed for this celebration at either end of the transcontinental line. And the instrument into which Dr. Bell talked was a replica of the first telephone, just a drum-head of animal-skin over a wooden revolver, the center of the drum-head joined to the free end of a receiver spring and a simple mouth-piece adjusted to the drum-head. And despite his blindness and the first crude instrument and the antiquated wire, the modern science of telephony was in practice for Bell to speak into the first transmitter and send his voice across the wire.

While the commercial in the specially leased room on the fifth floor of the Grant avenue building of the telephone company carries the unusual collection of the commercial line to the American public, it will not be ready for commercial use for some time, as there is much work yet to be done just as a ship is not ready to sail as its launching. But the simple are

after year the inhabitants will pile up. The completion of the great transcontinental line marks the beginning, not the end, of telephone expansion. Before Vail's dream is fully realized it will be possible for anyone anywhere in the United States to talk to any one else anywhere in the United States.

It was 1 o'clock San Francisco time and 4 o'clock New York time when President McForman of the Pacific Coastway noted himself at a table in the specially decorated

office on the sixth floor of the Pacific Telephone and Telegraph Company's building in Grant Avenue and took up the receiver of the telephone. The guests who had been invited to be present at the significant ceremony, including state and city officials, representatives of civic bodies, telephone officials, scientists, engineers and newspaper men, "were all attention."

"Hello, New York, hello, yes, I hear you," said Mr. McFarland. "Can you hear me?"

Then Mr. McFarland stood up and motioned to Mr. Watch. The men worked. The sound waves were vibrating across the continent and reforming themselves into words in the San Francisco receiver.

It is fitting that the first conversation over the wires should be between Dr. Alexander Graham Bell, inventor of the telephone, and Thomas A. Watson, who made the first telephone and who first heard spoken words over a wire. Dr. Bell was in the office of the American Telephone & Telegraph Co., at 26 Bay St. New York while Mr. Watson was on the sixth floor of the Grant Ave. building in San Francisco.

After Mr. Watson had ended his talk with Dr. Bell the mayor of the Western metropolis exchanged greetings with the mayor of the Eastern Metropolis.

Among those present as guests of The Pacific Telephone and Telegraph Company in the Telephone building at San Francisco to witness the celebration of the opening of the transcontinental line were Judge W. W. Merwin, Mayor James E. Rolph Jr., Wm. H. Crocker, H. I. Pillsbury, H. T. Frost, Wm. Sprague, R. P. Schwartz, J. A. Brantun, S. P. Eastman, J. L. Langer, E. S. Anderson, H. H. De Young, Wm. Woodhead, Wm. Hays, R. H. Hale, D. E. Shaw, Saml. A. W. H.

stration in New York were: Dr. Charles W. C. Chubb, Dr. Chamberlain H. Brown, Dr. Samuel Jones, Dr. Admon, Dr. Charles H. A. Adams, William A. Martin, Francis L. Hays, H. L. Hays, George H. Hays, Seymour H. Hays, Clarence H. Hays, Joseph H. Hays, A. Martin Hays, Benjamin Strong, Jr., and Albert H. Hays.

WEDNESDAY, JANUARY 27, 1915

## A TELEPHONE TRIUMPH.

## Long Distance Line Installed Between the Atlantic and Pacific.

**S**AN FRANCISCO can now call up or be called by New York or Boston over the telephone. For 3635 miles the human voice can carry over the wires as distinctly as though it were being borne by the same medium to the next street. Bell, the inventor, and Watson, the maker of the first instrument, greeted each other across the continent with the clearness which marked their exchanges over a two-mile wire thirty-nine years ago, when the telephone was first tested. The President spoke his good wishes to the city, and The Chronicle received and replied to communications by voice from Atlantic Coast contemporaries.

It is a scientific achievement, but those who may be disposed to regard it as that only should be reminded of the commercial deception with which the first telephone was received. Few beside the inventor foresaw the use to which the instrument would be put. Even Bell and his enthusiastic associates failed to anticipate of a single 20th-century building about nine million telephones.

The men who have put their capital into this trans-continental line must be as shrewd as they are enterprising. They have calculated the demand for ocean-to-ocean communication, as well as possible competition from other devices. Knowing that the limit of the wire-line telephone is 400 miles, they are perfectly satisfied to take chances with a margin of 3000 miles.

It will be no line for frivolous gossip, but it should be in pressing demand for urgent commercial, financial and other communications.

**THOMAS A. WATSON**  
Bell's Associate

many called another large sum to civilization's indebtedness to the Indians, to Alexander Graham Bell, the inventor, to Thomas A. Edison, the maker, to Theodore Tilton, the man whose genius as a business organizer has built out of that first 200-foot line a system that includes 9,000,000 telephones, and to J. J. Clark, the engineer who has made trans-continental telephony possible.



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**PAGE**

Page 83 of Kendall's Note book No. 26

Found it made no diff. if killed and in 88  
output elct. is <sup>313</sup> ~~input~~ across input  
313 then both ways. 314 only with other  
one killed

decided to go to N.Y. took all audions except  
253, 257, 272.

More information regarding loading on P.C.W.D.  
near Marion - Marion is practically at  
a loading point.

also Pauls 11-12, 19-20, 27-28, loaded west of T.B.  
and 5-6 loaded east of T.B. in Marion East  
station

Marion is  $\frac{2}{3}$  dist from here to Chi.

139 mi from Chi. - Chi is 535 from Bgh.

Marion loop = 692 mi.

Pairs 13/6 loaded 2 poles west of Marion station

Marion is evidently a good point to loop -

5/6 to any of those whose loading is west of  
Marion T.B.

Pgh. 3/10/14. Aired, to put in 114 B audions,  
with higher B current, - cells in Cabt, high  
first resistance across high side of input to.  
adjusting gain by tapping off part of this for  
the grid. Checked high res. coils - all  
about 5000  $\Omega$  each. Shunted microammeter.

Readings ~~measured~~ <sup>air.</sup> 9:55 AM - 10:15 AM.  
Resistor about 11.5  $\times 10^4 = 115 \text{ ohms}$  578 500 1000  
new about 23  $\times 10^4 = 230 \text{ ohms}$  200 125 340  
1 dir = 27 25.1 mA 28.6 28.5 29.4

Ratio is 1:3 6.2 1 dir = 30 mA.  
Full scale = 3 mA.

Earlier readings - some thermal effect - due  
to recent soldering.

Test of some audions - with 6  $^{\circ}$  cells -  $I_g = 2 \text{ mA}$ ,  
 $I_g = 1.7^{\circ}$

hi = output transformer usually connected - both sides in  
series

End R	Jan.	#	R.	Jan.
348	250,000	10	396	250,000
	150,000	8		200,000
	100,000	4		150,000
	100,000	6		100,000
				125,000
				175,000

with output transformer changed to have high side in II.

End R	Jan.	#	R.	Jan.
348	150,000	4	396	200,000
	250,000	7		250,000
	250,000	9		225,000
	225,000	10		175,000



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**PAGE**

MARCH 23 1914

MUNDAY

§ 32 \* 9 on Audion circuit.

This is the first day of series of new audion and modified audion circuit.



Also the filter is correct, and resonant circuit taps for higher cut placed on "repeat" contacts instead of on bridge contacts as formerly. - (Ringer tap put through O.K.) and "C" all are made instead of 2 and then polarity reversed (- on grid)

Audion 400 repeats in Ball  
399 " " N.Y.

400 - 1.6 - 6" (75 ohm) - 73" (11") - 2000 - R=2  
399 - 1.6 - 6" (75 ohm) - 84 (92") - 2000 - R=2

920 Two calls put in  
Quality seems all the  
could be desired, no  
trouble to hear.

no metallicness at all.

about a two percent

decrease in space currents during summer, was  
noticeable in audion 399 then in 400

920 Conversation on business topics finished, 1 up 12

920 Spring 4126 - Party out Ball

920 Operation repeats 1 am, several times

920 Business talk - no trouble to hear.

10 - Man and lady talk, short ball

920 No talk

920 No talk - while the sun

call put

1027 400 - 1400 - 399 - 1460

1027 Two men talk - O.K.

1127 N.Y. again talks with Wilmington.

1127 A long N.Y. Ball conversation

1127 Two men talk with Wilmington O.K.

op - 1 " p / 1

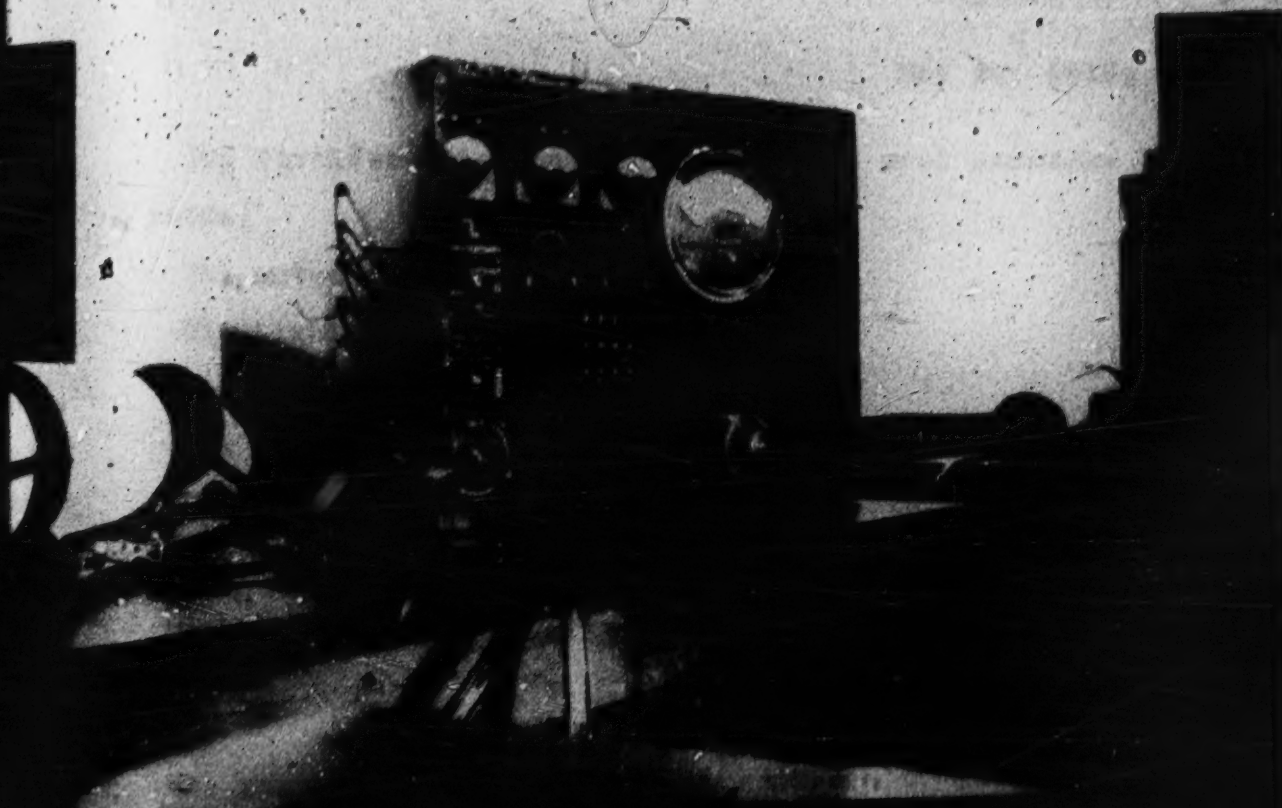


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## PLAINTIFF'S EXHIBIT No. 18

Photograph of the radio receiving set used in the 1918  
Radio Telephone Tests





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Wilson memorandum and drawings relating to the 1915  
Radio Telephone receivers

Case D 1233

May 26, 1915.

The Wireless Telephone Receiver to be used consists briefly  
of five parts:

- (1) The antenna circuit
- (2) The high frequency amplifier
- (3) The rectifier
- (4) The low frequency amplifier
- (5) The stopper

The arrangement of apparatus is shown diagrammatically in  
Figure 1. Detailed drawings of the various parts are given separately.

1. The Antenna Circuit - (Figures 1 and 2)

The antenna is connected in series with a coil whose inductance is adjusted to suit the antenna used, a Marconi and a Blitzen condenser. A resistance of about 1,000,000 ohms is placed in parallel with the condensers. On account of its high value this resistance does not interfere with the passage of the high frequency currents through the condensers, and at the same time it allows any static charge which might tend to accumulate on them to flow to earth. The condensers may be joined either in series or parallel by means of the knife switches shown.

2. The High Frequency Amplifier - (Figures 1, 2, 3, 4)

The coil "A" of the antenna circuit is loosely coupled with another coil "B" of about 25 H. E. inductance which forms part of an oscillatory circuit whose tuning is affected by means



of a Blitzen condenser.

The terminals of this condenser are connected to the input circuit of a vacuum tube repeater.

The vacuum tube repeater being essentially a device in which the output current is controlled by the input voltage, it is desirable to have its input internal resistance as large as possible.

Since the current in the tube is caused by the passage of electrons from the filament to the grid, the resistance may be made practically infinite by maintaining the grid at a negative potential with respect to the filament. This is accomplished by means of the  $4\frac{1}{2}$  volt battery C.

The plate of the vacuum tube repeater is maintained at a potential of about 150 volts by means of the battery D. The battery is connected in series with a choke coil (44-B) and shunted by a 2 m. f. condenser which will allow the high frequency currents to pass.

The connections of the filament circuit are obvious from the figures.

Owing to electrostatic action between the plate and the grid the circuit is liable to sing. This is corrected by means of the small coil E which is connected in series with the output coil and provided with long leads so that it can be brought into the neighborhood of the coil B. The singing of vacuum tube repeaters is due to the mutual influence of the grid and plate circuits. By properly adjusting the coupling of coils E and B, the magnetic induction can be made equal and opposite to the electrostatic and

-3-

hence the singing may be stopped.

The output from the vacuum tube repeater is fed into a second oscillatory circuit "Y" and the external output impedance and hence the energy output may be varied by adjusting the coupling between this circuit and the output coil.

A switch is provided and is shown in detail in Figure 3 by means of which the antenna may be connected through the first tuned circuit directly to the rectifier.

### 3. The rectifier

The transmission of speech is accomplished by the variation of the amplitude of a high frequency wave. This is represented diagrammatically in Figure 5. The high frequency oscillations are produced by the generator and the envelope of the waves represents the voice vibrations.

Before these vibrations can be made audible at the receiving end it is necessary to modify the waves again so that a telephone receiver can translate them into speech sounds.

On account of its high impedance to waves of high frequency the telephone receiver will not transmit the short waves, and further any ordinary telephone diaphragm would refuse to respond to such high frequency waves on account of its inertia.

If however, the modulated wave is rectified only half of the wave will be left and since the high frequency oscillations are much too fast for the receiver diaphragm to follow, this latter will follow a path dependent only on the amplitude of the oscillations, i.e. will vibrate in a manner corresponding to the speech vibrations.



The amplified high frequency current is therefore next sent through a rectifier which consists of a high impedance vacuum tube repeater. The terminals of the condenser in the circuit "F" are connected to the input of this tube, one terminal being connected to the filament and the other through a Marconi condenser to the grid. The use of the condenser is explained below.

The connections of the plate circuit are obvious from the diagram. The introduction of the 2 m. f. condenser is as before to save the high frequency from the necessity of passing through the battery. The 43-A choking coil is inserted to prevent inconstancy of working due to local troubles in the batteries and to make possible the use of a common "B" battery for the two tubes.

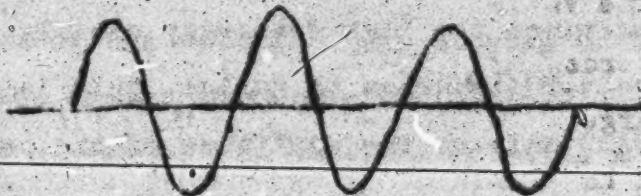
The action of the rectifier may be best understood from a consideration of the D. C. characteristics.

The connection between output current and input voltage for a vacuum tube repeater is shown in Figure 6.

Now consider an arrangement of apparatus such as that shown in Figure 7, i.e. without the condenser used in practice.

Let the applied A. C. voltage oscillate between the extreme equal values O L and O M. Owing to the curvature of the characteristic the increase of current due to the increase of voltage to O L will be greater than the decrease due to the decrease O M.

Hence an input which is quite symmetrical such as



-5-

will come out as a distorted wave such as:



Since the current in one direction during one half of the cycle is greater than the current in the opposite direction during the other half there will be a D. C. component which is proportional to the amplitude of vibration and hence in the case of the rectified high frequency these currents follow the contour of the envelope.

Now consider the circuit shown in Figure 8 where a condenser shunted by a high resistance is placed in series with the grid.

If the A. C. were not applied the current would have a definite value represented by O N, Figure 8.

This would be constant with respect to the time and is represented by ab, Figure, 9.

On application of the A. C. the grid voltage rises to an amount O L with the first vibration. This tends to increase the space current but owing to the fact that the current through the tube is caused by electrons, the charge on the grid is immediately neutralized and the current does not rise much above its original value. This neutralisation of the positive charge leaves then a certain amount of negative electricity in the grid connections. When the A. C. swings to the value O. M. a certain amount of negative electricity will be forced on to the grid, and this together with the negative charge left there will bring the grid to a lower potential than it would have had if the condenser had not been in the circuit. This will cause the output current to decrease considerably since the negative electricity cannot be neutralised by the electron



stream. The output current will therefore be as shown by bc, Figure 9. The dotted line represents the average current.

When the A. C. is out off the current will not immediately return to its original value unless some means is adopted to get rid of the residual negative charge in the grid connection. This is done by shunting the condenser with a very high xylol resistance. This resistance charge to remain while the high frequency oscillations are taking place, but to allow the residual charge to leak away as soon as the oscillations stop.

If then a train of waves strikes the detector, it gives rise to a rectified current which is proportional to the amplitude of the waves. If the amplitude changes, the current follows the change in amplitude.

In the case of the transmission of speech, the amplitude of the waves follows the vibration of the voice and hence the D. C. current obtained follows the speech vibrations.

The output is sent through an amplifying set which increases the intensity of the rectified current. Since the amplifying set is essentially a device in which the output current is controlled by the input voltage it is essential to have this latter as large as possible. This is accomplished by sending the output current of the rectifier through a high impedance 400,000 ohms. In this way the total available power from the rectifier is not used but the maximum voltage output is obtained.

#### 4. The Low Frequency Amplifier - (Figures 1.10, 11, 12).

The output from the rectifier is connected to the input of the

-7-

of the low frequency amplifier set. This consists of two vacuum tube repeaters in series whose action is similar to that of the high frequency amplifiers.

The output from the first vacuum tube repeater is passed through the low side of a 10 to 1 transformer "G" whose impedance is approximately that of the internal output resistance of the tube. The secondary of this is connected to the input of the second vacuum tube repeater and the output of this is led directly into the stopper. The input to the second vacuum tube repeater may be varied by means of the variable resistance "H".

By means of the double throw triple pole switch shown in Figure 10, either one or both vacuum tube repeaters may be used as required.

#### 5. The Stopper - (Figures 1,13,14,15).

The stopper is a device for limiting the amount of telephone energy which is delivered to the telephone receiver. In wireless telephony irregularities are introduced by static discharges to the antenna. These are occasionally so large as to mask the signals completely. The stopper is so arranged that it will not allow signals of more than a certain intensity to pass through. The adjustment is made so that all signals louder than the speech signals will be cut off and hence the accidental noises cannot be louder than the speech signals.

A simplified drawing of the circuit is shown in Figure 1. The centre of a split inductance "J" is connected to the filaments of two vacuum tube repeaters. The ends of the inductance are connected to the grids. When an impulse comes along, it causes the potential of one of the grids to rise and that of the other to fall. This causes

16  
16  
19



a corresponding increase of current in the first audion and a decrease in the second. This in effect is the same as superposing a current on the normal output current as shown by the arrows.

The output circuits of the two vacuum tube repeaters consist as shown of a battery, high adjustable resistance  $X$  and two coils wound so as to have the same magnetic polarity when the superposed current flows through them.

Owing to the fact that the vacuum tube repeaters can only transmit current in one direction, it is impossible to do more, by any impulse than to decrease the current in one vacuum tube repeater to zero. The current in the other tends to increase owing to the increase of potential on the grid.

On account of this rise of current the resistance of the tube decreases and since the output circuit contains a very high resistance, the voltage across the tube decreases. The circuit is so arranged by adjusting the resistance " $X$ " that the fall of potential finally becomes so great as to prevent the rise of current above a certain amount.

If this amount is made approximately equal to the current required to transmit the talk, the interfering sounds due to accidental causes cannot possibly be of greater intensity than the speech.

By means of the triple pole double throw switch shown in Figure 13, the stopper can be thrown in or out of the circuit at will.

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CIRCUIT SPECIFICATIONSANTENNA CIRCUIT

Antenna inductance 6 to 25 M. H. according to stations.

Marconi Condenser.

Blitzen Condenser.

Shunt Resistance 1,000,000 ohms variable.

HIGH FREQUENCY AMPLIFIER

Type M Vacuum Tube Repeater

FILAMENT CIRCUIT

Storage battery 6 volts

Rheostat 3 ohms.

Current about 1.6 Amperes.

GRID CIRCUIT

Battery negative to grid  $4\frac{1}{2}$  volts

1 Ever Ready Tungsten Battery

Oscillatory circuit

{ Inductance 25 M. H.

{ Blitzen Condenser

PLATE CIRCUIT

Battery about 150 volts.

Choke Coil 44-B (10 henry)

Shunt Condenser 2 M. F.

Output coil 20 M. H. variable and

Compensating Coil. Small inductance

Current 8 to 10 milliamperes.

RECTIFIER

High Vacuum Tube Repeater Type D

FILAMENT CIRCUIT

Storage battery 6 volts

Rheostat 3 ohms.

Current 1.6 Amperes.



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-2-

GRID CIRCUIT

Oscillatory circuit { Inductance 25 M. H.  
Blitzen Condenser  
Marconi Condenser  
Xylol Resistance

PLATE CIRCUIT

Battery about 250 volts.  
Choke Coil Special 43 A 100 H.  
Shunt Condenser 2 M. F.  
Resistance 400,000 ohms.  
Current 300 Microamperes

LOW FREQUENCY AMPLIFIER

Two Type M Vacuum Tube Repeaters  
First V. I. R.

FILAMENT CIRCUIT

Battery 6 volts  
Rheostat 3 ohms.  
Current 1.6 Amperes.

GRID CIRCUIT

Battery  $4\frac{1}{2}$  volts negative to  
grid. 2  
Resistance 800,000 ohms.

PLATE CIRCUIT

Battery 150 volts.  
Choke Coil 44-B 10 H.  
Shunt Condenser 2 M. F.  
Primary of 10 to 1 voltage  
Transformer W 187  
Current 1.6 Amperes.

## 2nd Vacuum Tube Repeater

FILAMENT CIRCUIT

Battery 6 volts.

Rheostat 3 ohms.

Current 1.6 Amperes.

GRID CIRCUIT

Battery  $4\frac{1}{2}$  volts negative to grid  
Secondary of 10 to 1 voltage  
transformer W 187. (6)

Connected across 500,000 ohms

Variable resistance.

PLATE CIRCUIT

Battery 150 volts.

Choke Coil 44-B 10 H.

Shunt Condenser 2 M. F.

Output across 44-B choke coil

and condenser fed into primary

10 to 1 voltage transformer W 187

Current 8 to 10 milliamperes.

STOPPER

Two similar Vacuum Tube Repeaters M Type

FILAMENT CIRCUIT

Storage battery 6 volts.

Rheostat 3 ohms.

Current 1.6 Amperes.



GRID CIRCUIT

Battery 9 volts negative to grid closed through secondary of 10 to 1 voltage transformer W 167 shunted by 500,000 ohms.

PLATE CIRCUIT

Battery 150 volts.

Choke Coil 44-B 10 H.

Shunt Condenser 2 M. F.

Variable Resistance 240,000 ohms.

Primary of output transformer.

Secondary of transformer through 1 m. f. condensers to telephone.

Connection between the various parts of the receiving apparatus are often made by condensers. These are shown in the sketches and their capacities are about 1 M. F.

TUNING ROUTINE

1. Tune the circuits to the frequency to be received by means of the auxiliary oscillator.

2. Adjust the high frequency amplifier and rectifier so that they do not sing.

This may be accomplished by adjusting the coupling between the coils A and B (Figure 1). The direction of the current in the feed back coil may be reversed by means of the switch. Figure 4.

3. Alter the coupling so that the set sings and detune slightly.

The beat note between the oscillations of the set and those of the sending should now be heard.

4. Tune the circuits until the pitch of the beat note is as low as possible.

The most sensitive circuit is the first oscillatory circuit and the tuning should be made by successively varying that circuit and tuning the others.

When the pitch of the beat note is lowest the circuits are most nearly in tune. Sometimes there is a range of tuning so low that the lowest beat tone is below the limit of audition. In such a case the center of the quiet zone should be chosen.

5. Vary the coupling of the feed back coil until the circuit does not sing.



The adjustment is not exact and the best reception is obtained when the coupling is as loose as possible consistent with no singing.

6. When these adjustments have been made the signals or speech of the sending station should be heard and the circuits tuned until they are loudest.

The external output impedance of the high frequency amplifier and hence the power output may be varied considerably by the coupling of the coils of the transformer F, Figure 1.

The coupling of these and of the coils A and B should be adjusted to produce the loudest signals.

The tuning is of course more selective the looser the coupling.

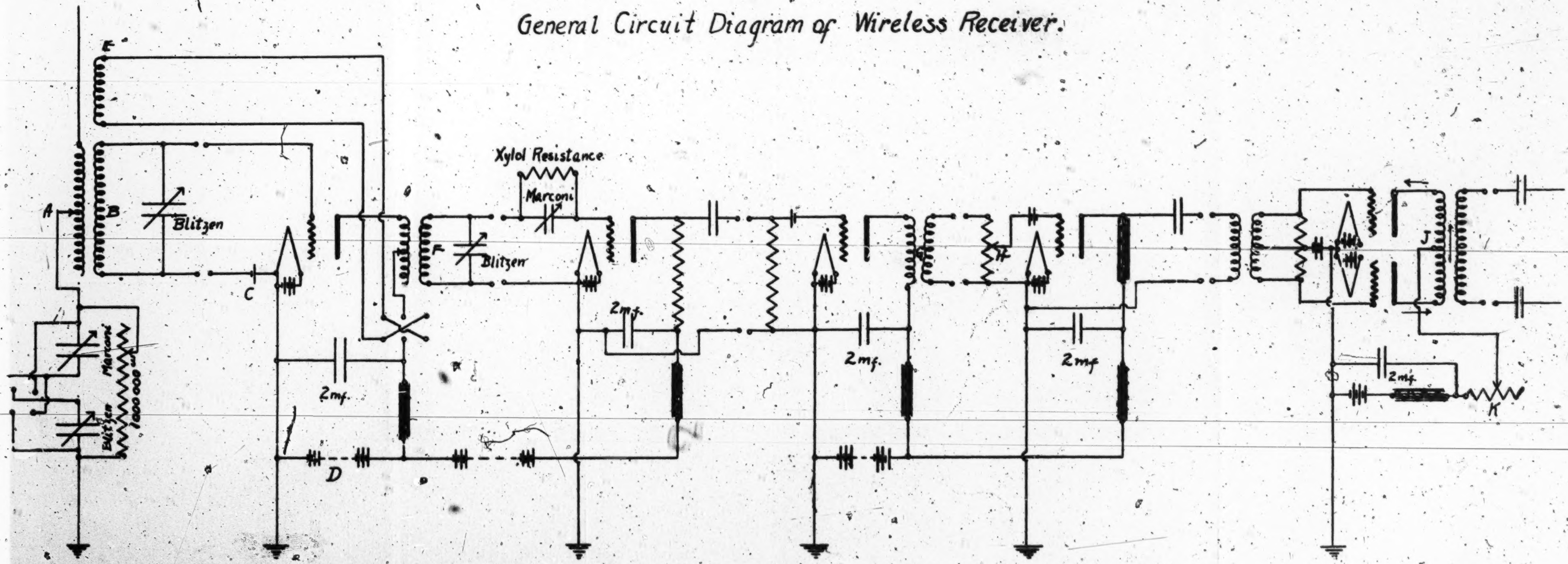
It is unnecessary then to strike a mean which will be determined by the working conditions between high selectivity and low intensity and high intensity and low selectivity.

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**PAGE**



# General Circuit Diagram of Wireless Receiver.



ANTENNA CIRCUIT X HIGH FREQUENCY AMPLIFIER X RECTIFIER X LOW FREQUENCY AMPLIFIER X STOPPER

FIG. 1.

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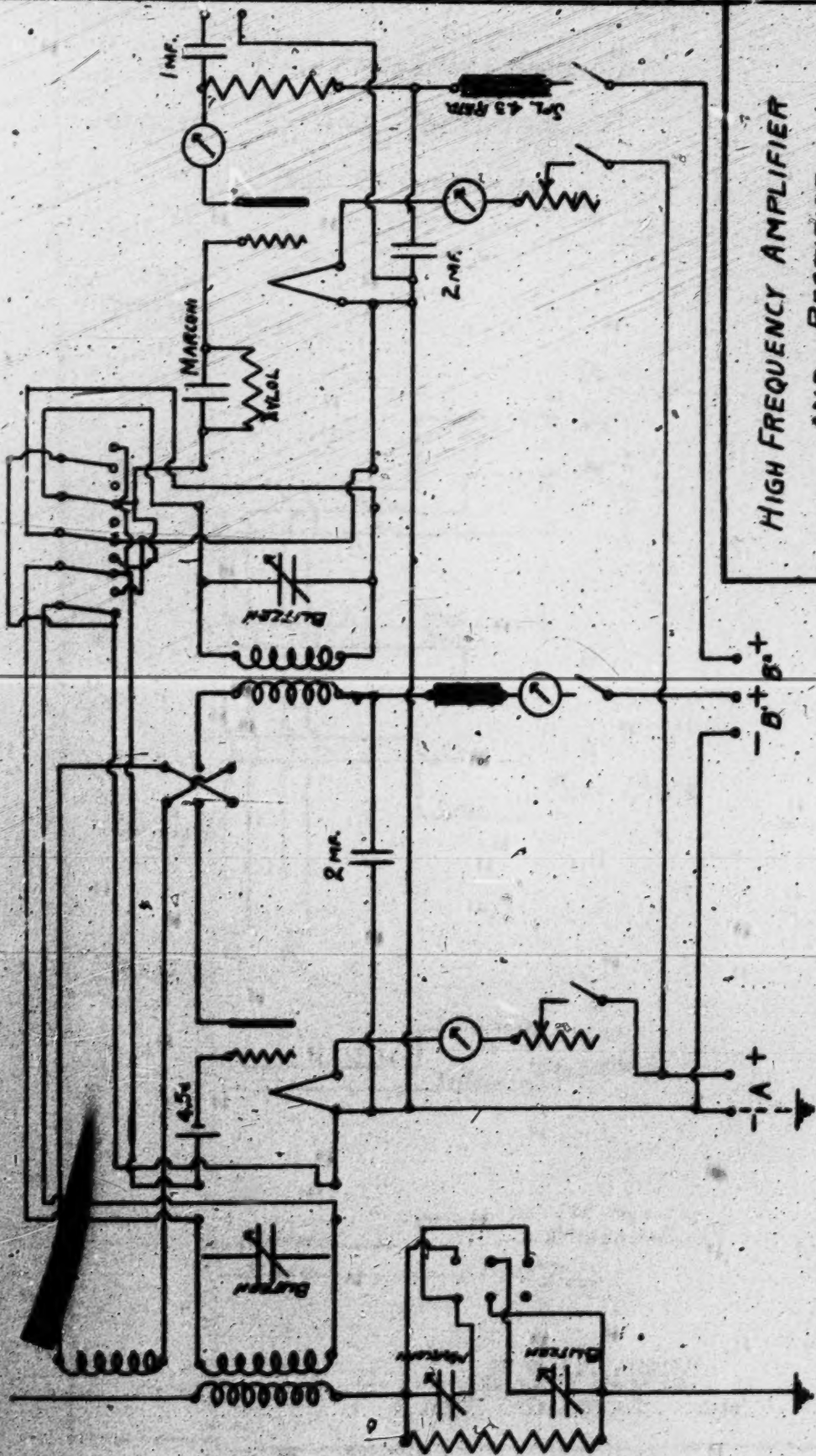


FIG. 2.

HIGH FREQUENCY AMPLIFIER  
AND RECTIFIER.

SCALE

APPROVED  
DRAWN BY D.H.M. CHECKED BY  
TRACED BY D.H.M. ENGINEER W.W.

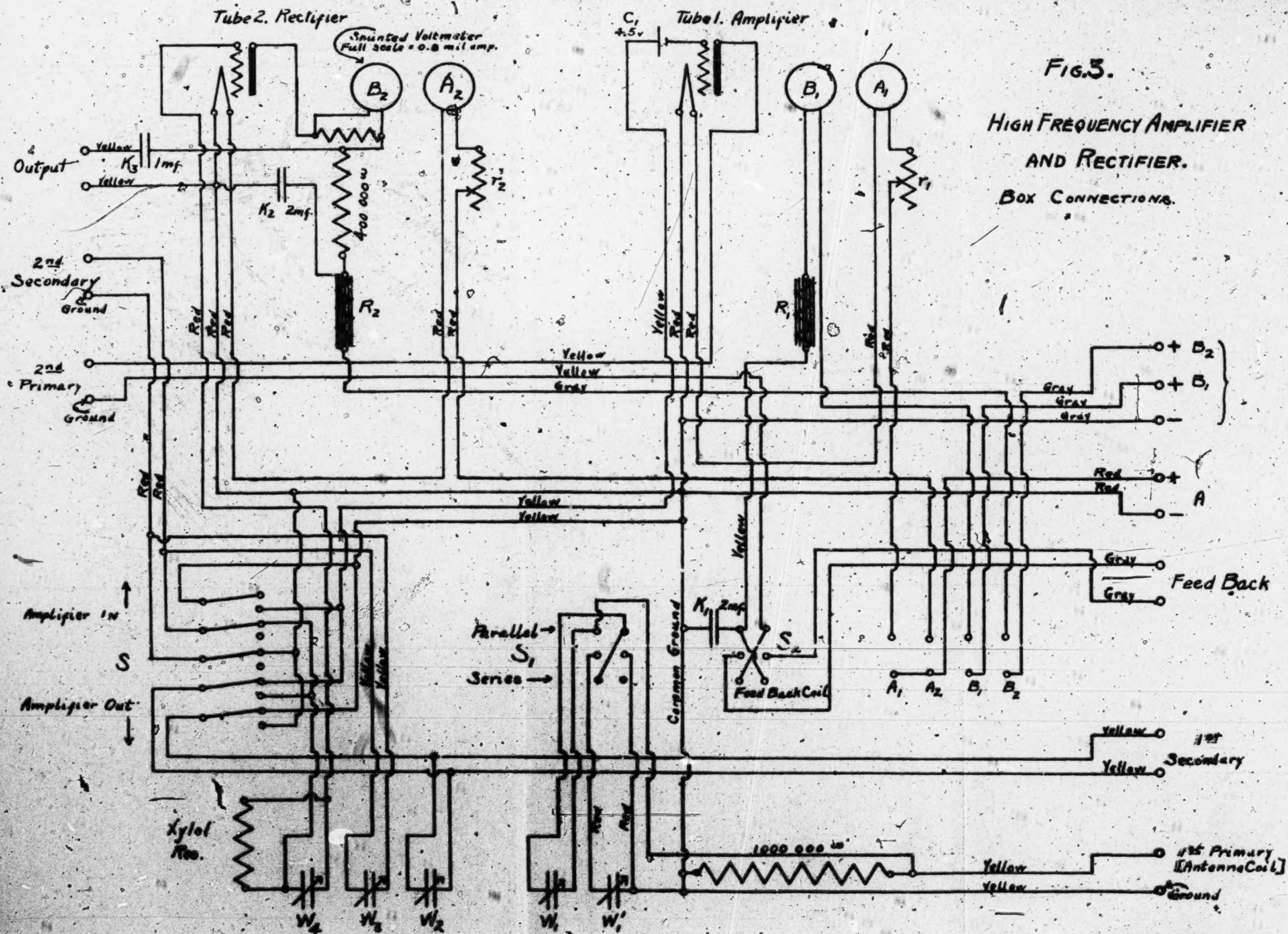
WESTERN ELECTRIC CO. N. Y. ENG. DEPT.

ES 160357

MODEL ENG. ISSUE

A





ES 160372  
L.B.C. 5-27-16 DNN.

LB.C. 5-27-16 R.M.W.



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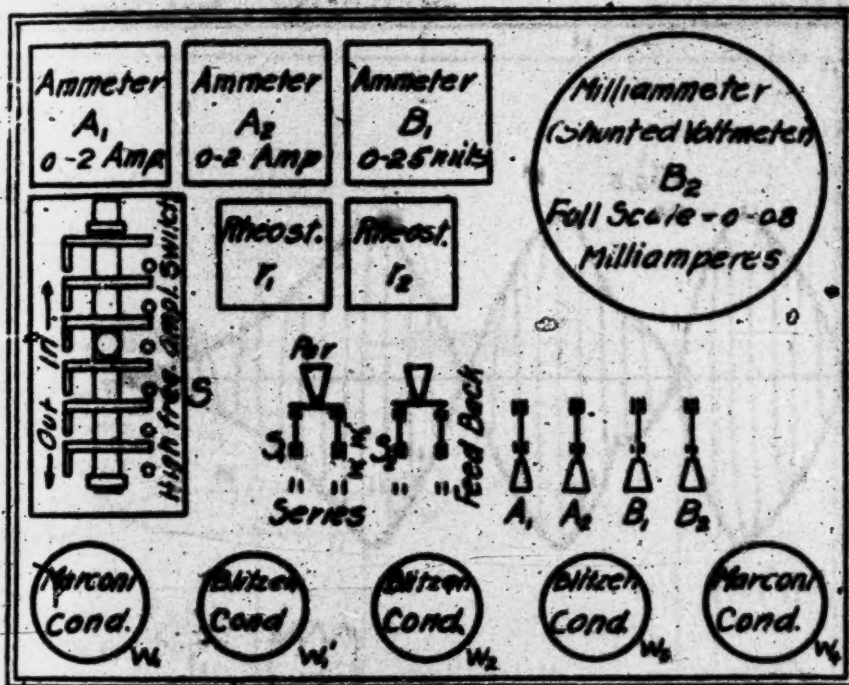
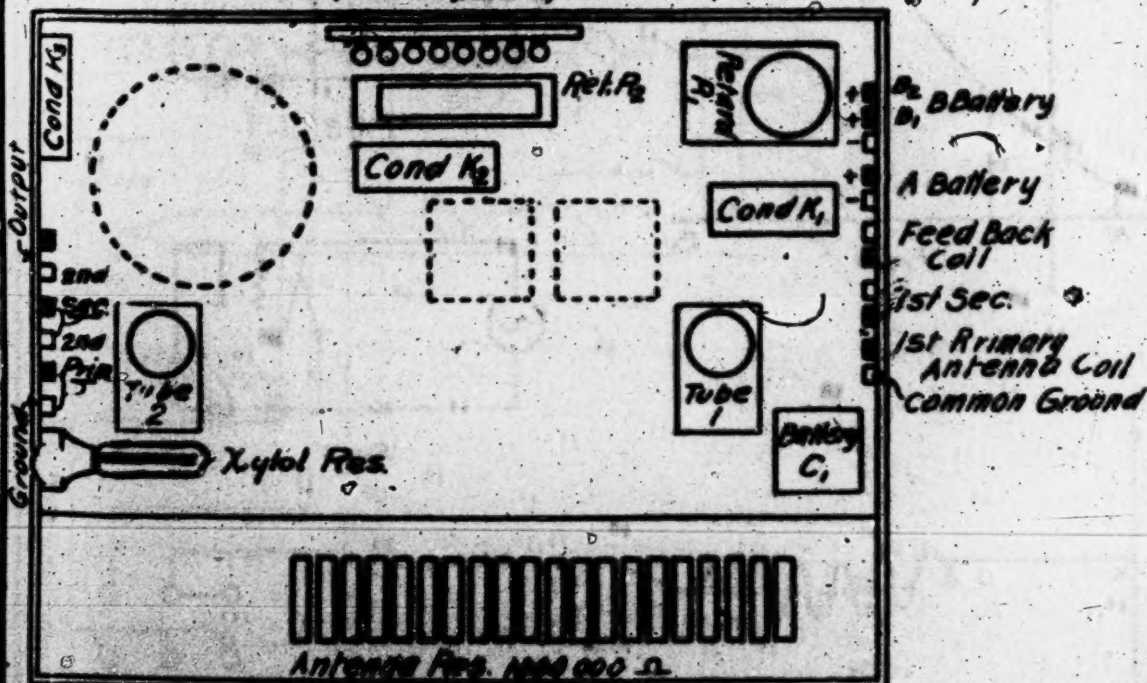


Fig 4  
High-frequency  
Amplifier and  
Rectifier  
Diagram of  
Box

Front

Output Res. Ind. 2; 100 000 Ω



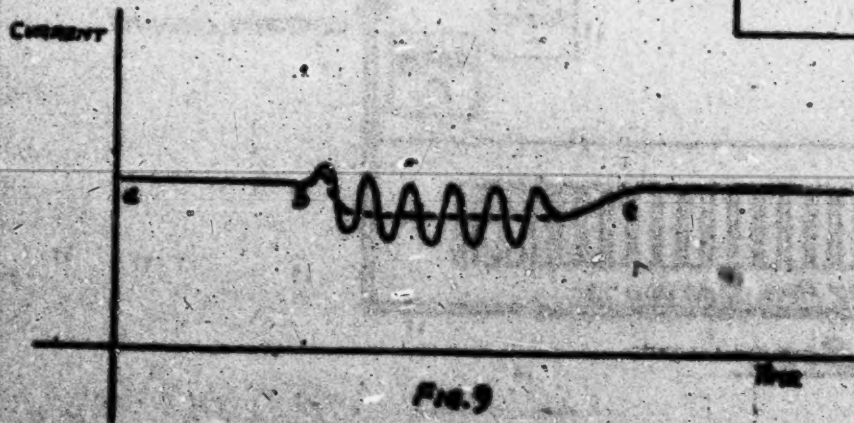
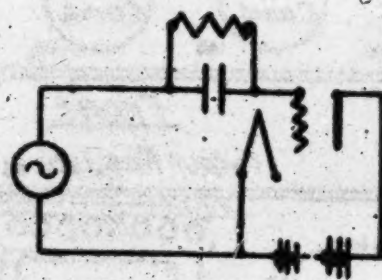
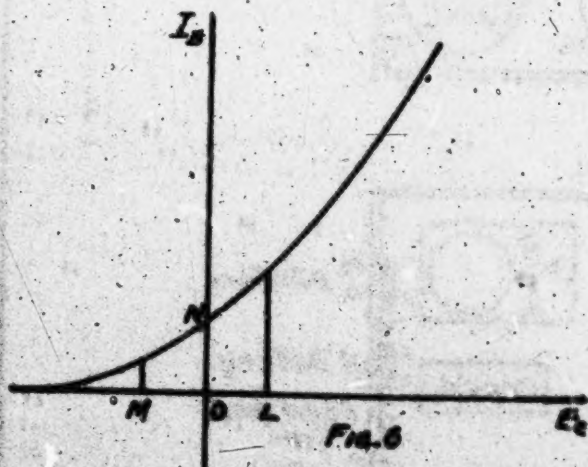
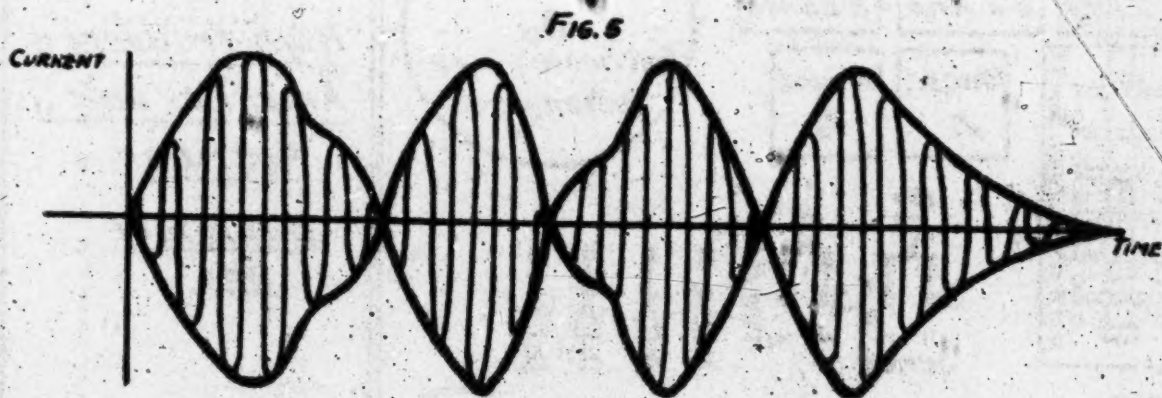
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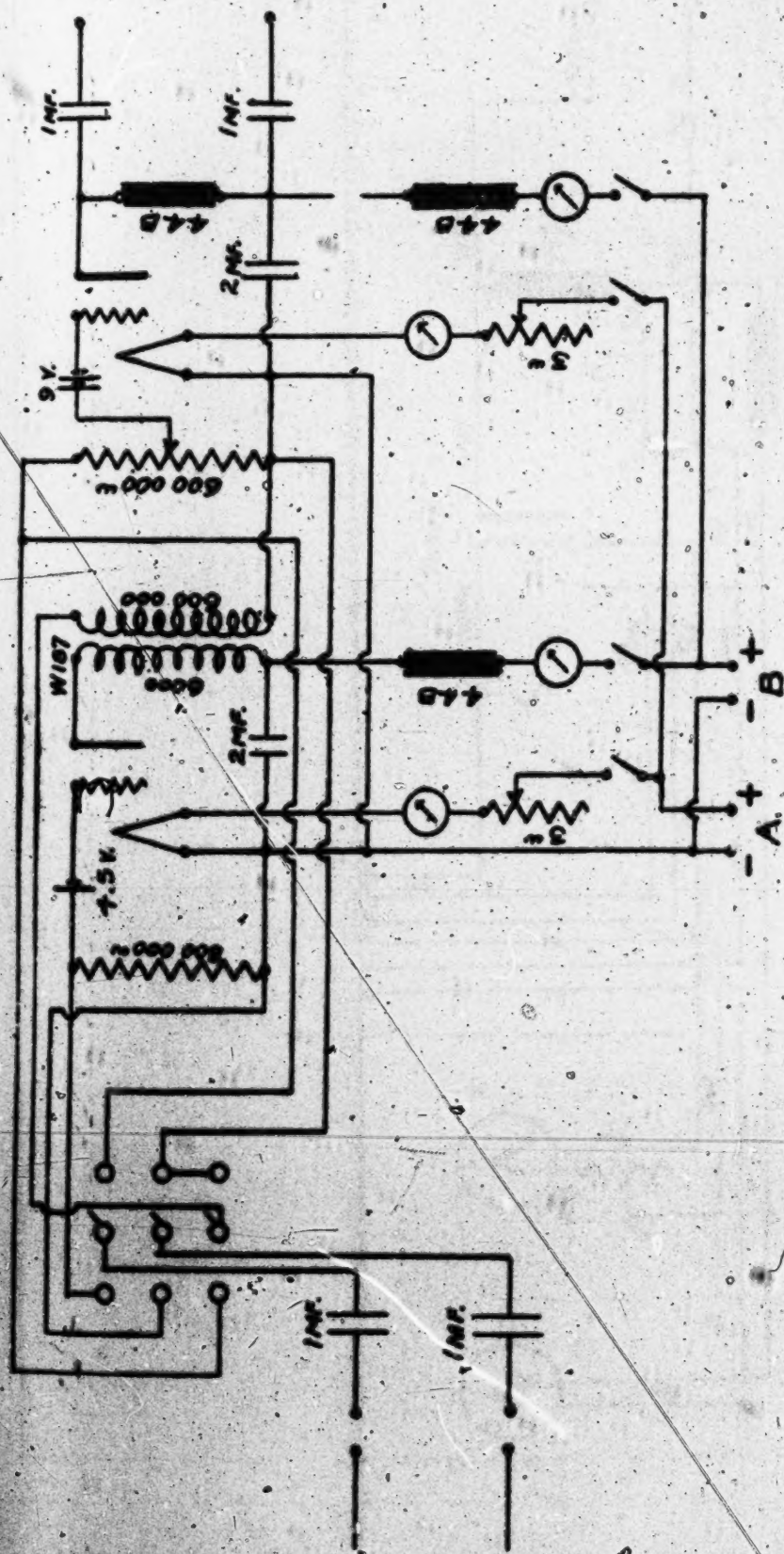


Diagram explaining and showing initial of 11 repeaters

WESTERN ELECTRIC COMPANY, NEW YORK U. S. A.  
ENGINEERING DEPARTMENT

SKETCH NO ES 160354





LOW FREQUENCY  
AMPLIFIER.  
[THEORETICAL]

SCALE

APPROVED

DRAWN BY D.M. CHECKED BY  
TRACED BY D.M. ENGINEER W.W.

TRACIO DE DYN. INGENIERA W.W.

WESTERN ELECTRIC CO. N. Y. ENG. DEPT.

**ES 160356**

**FIG. 10**



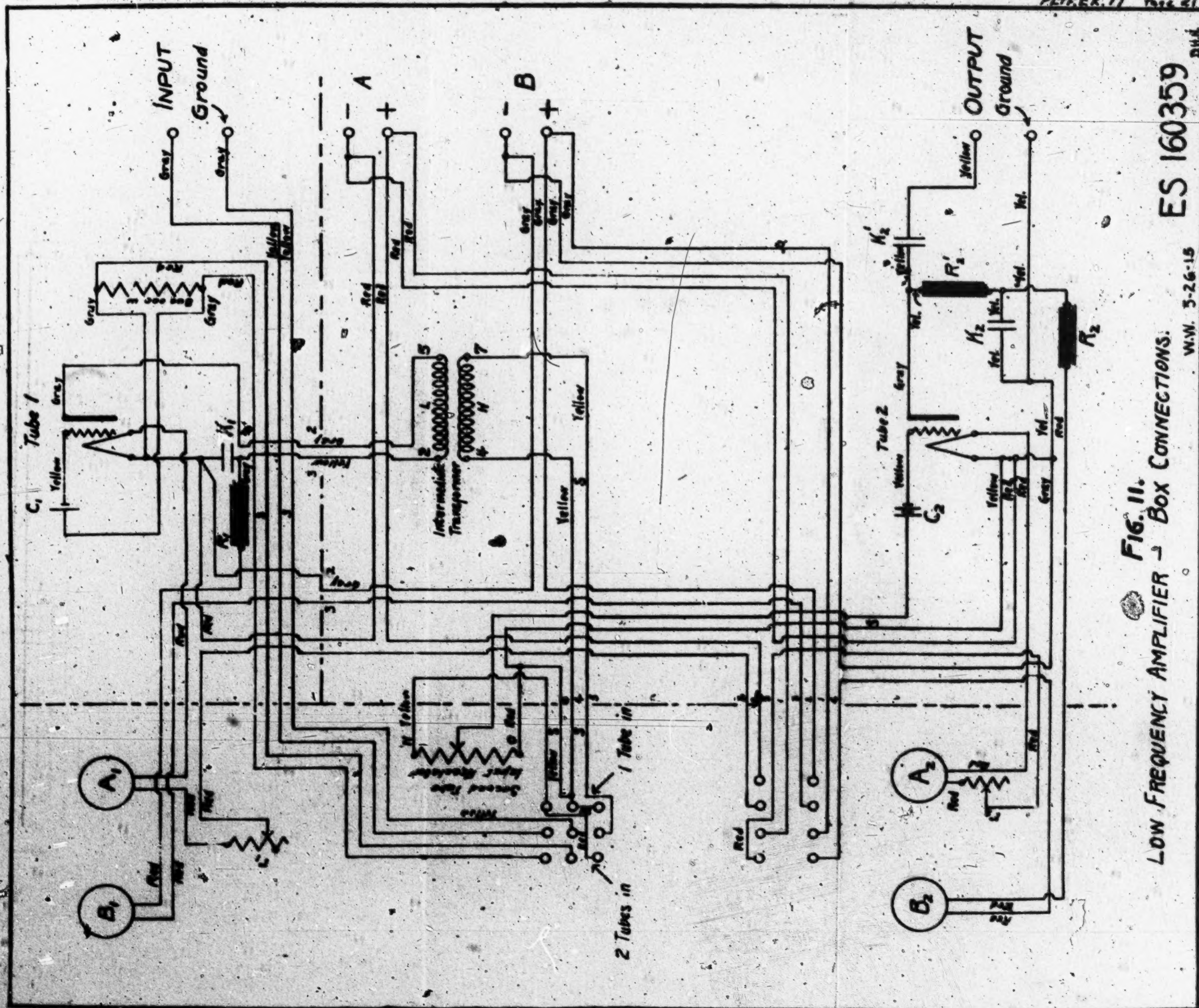


FIG. 11. LOW FREQUENCY AMPLIFIER - BOX CONNECTIONS.

ES 160359

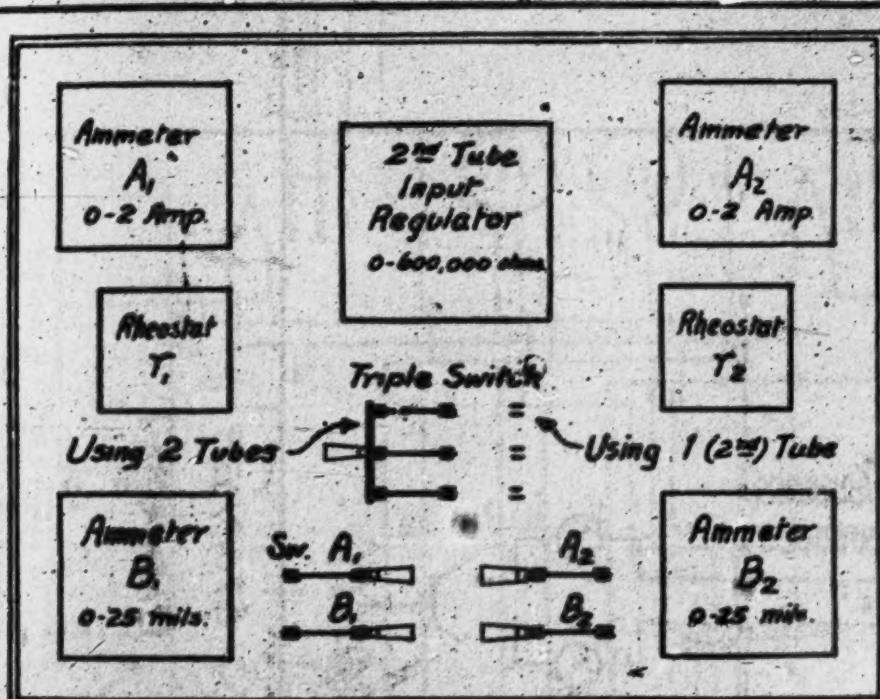
W.W. 3-26-15

D.H.

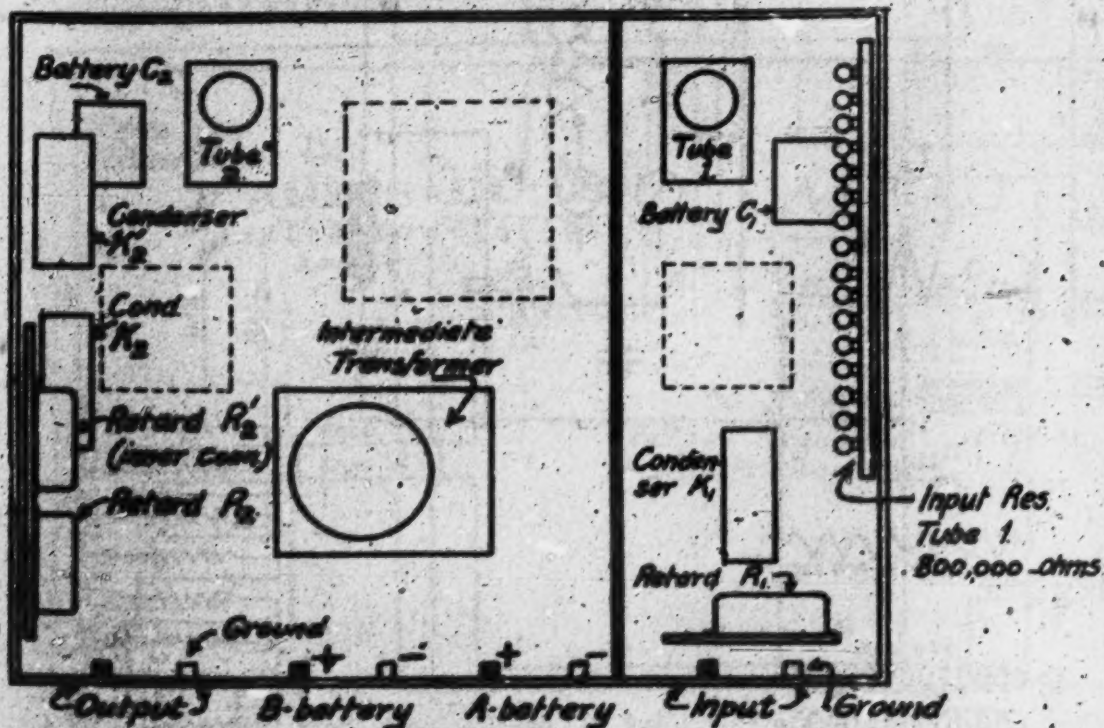
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- Front. -



- Back. -

IBC. May 26, 1915.





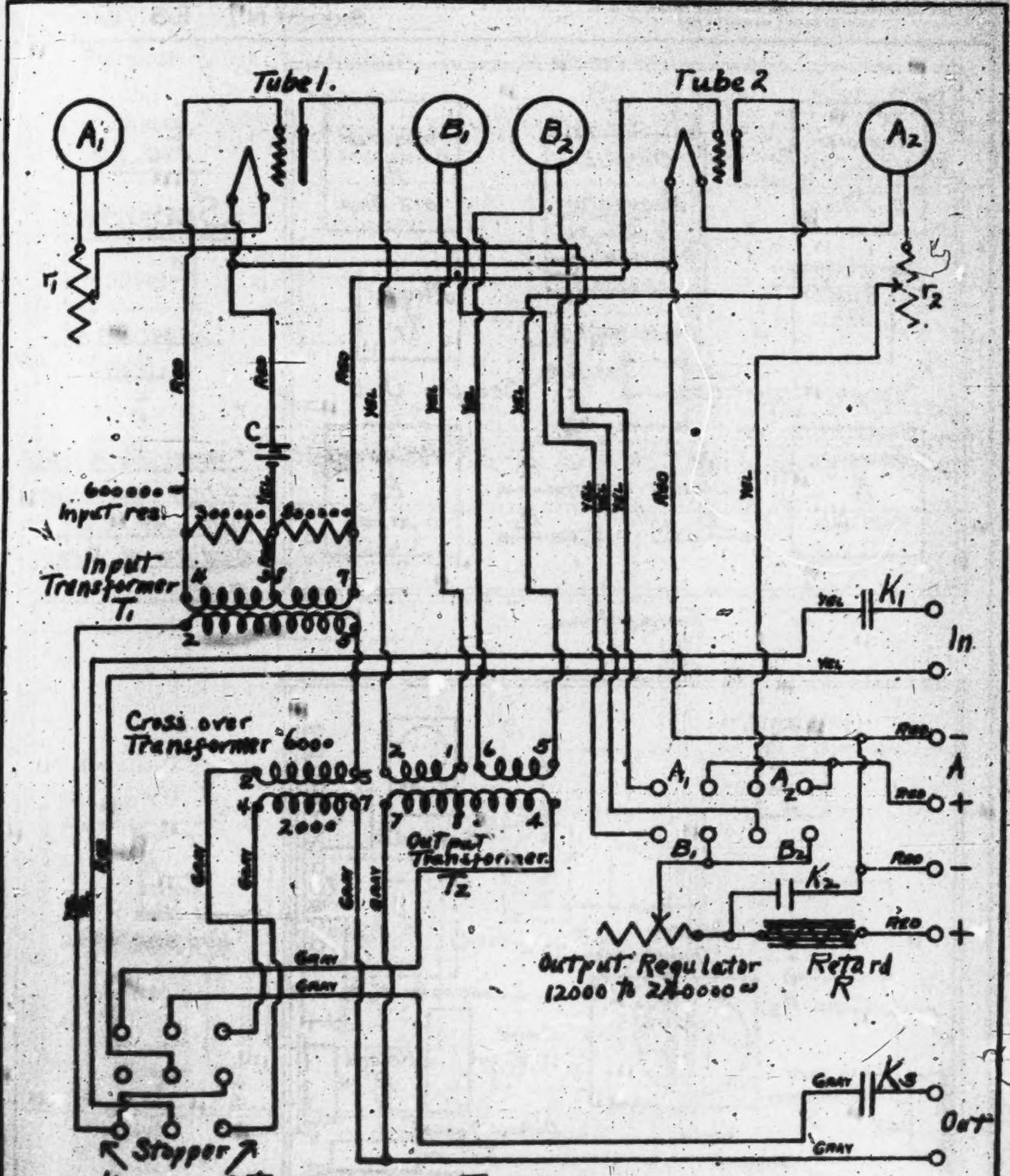
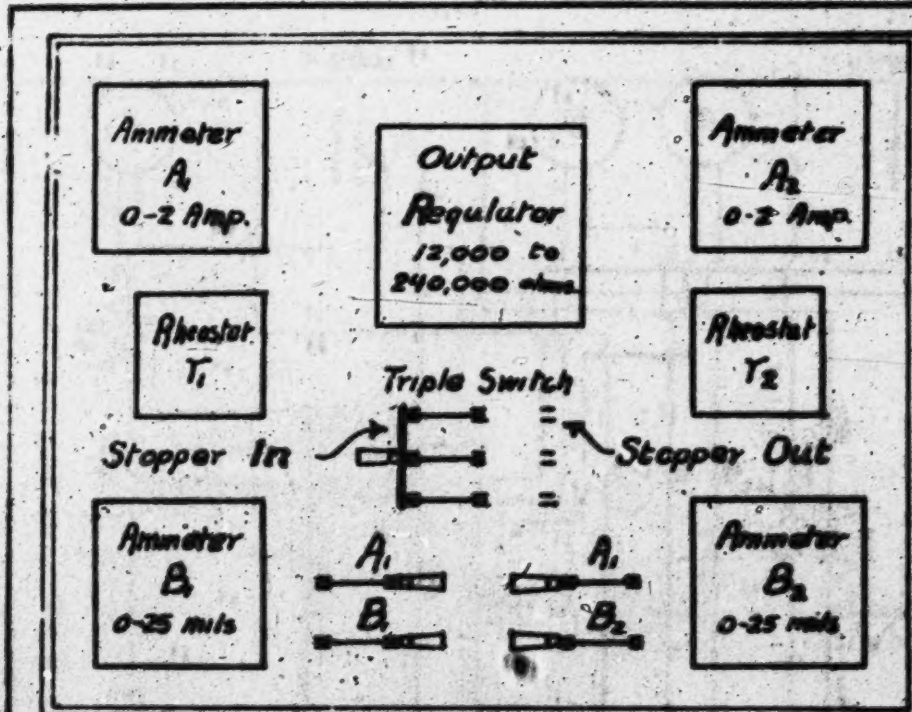


Fig. 14  
Stopper ~ Box Connections

NOTE: "YEL" = YELLOW OR BLACK.

IBC. 5-27-15

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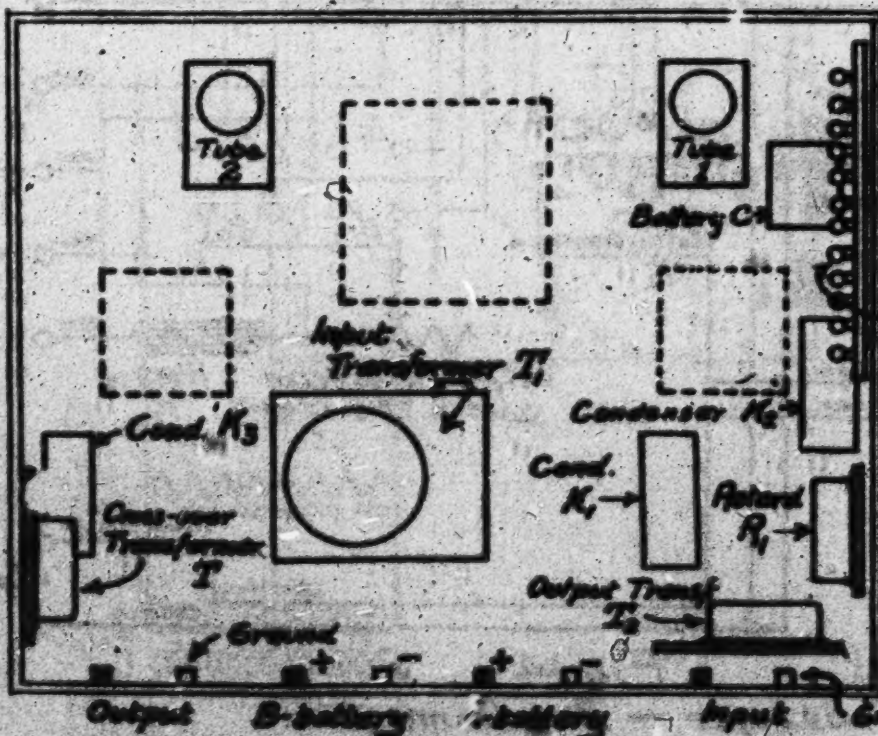


—Front.—

Fig. 15  
Stopper

Diagram of  
Box.

NOTE: Fig. 15 refers  
to first two stoppers  
built. See Fig 15a for  
diagram of later  
model.



—Back—



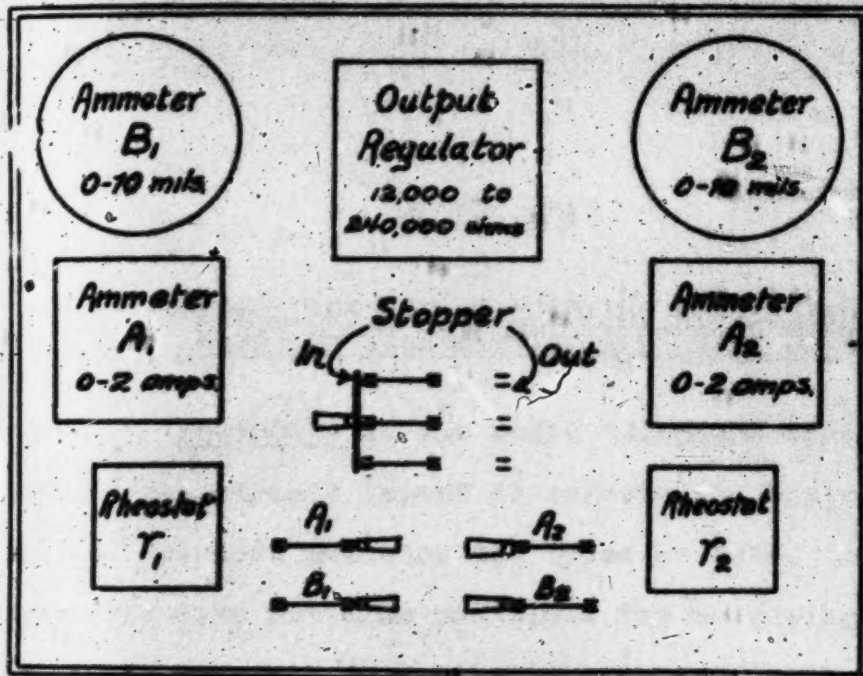
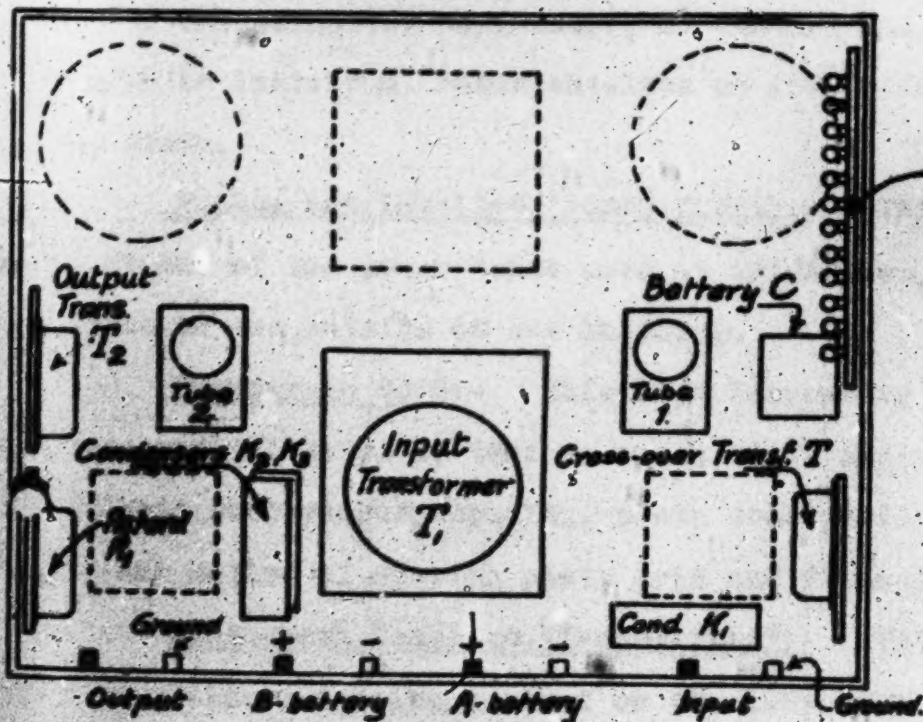


Fig 15a  
**STOPPER**

Diagram of  
Box.

Note: Fig 15a refers to  
3rd 4th 5th stoppers built;  
for diagram of 1st and 2nd  
see fig. 15.



IBC. June 2, 1915.

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## PLAINTIFF'S EXHIBIT No. 19

Heising memorandum of November 19, 1930 and photographs  
relating to the Arlington transmitter

65-145- November 19, 1930

INFORMATION AND PHOTOGRAPHS CONCERNING THE  
ARLINGTON TRANSMITTING EQUIPMENT OF 1918

ES-450074 is the radio telephone transmitter circuit showing the circuit layout as regards the basic elements in the system. It does not show the types of tubes in the different sets. It does not show positions for measuring currents or voltages. It does not show circuit breakers, switches, nor methods of connecting the tubes in groups of 50.

The elements, oscillator, modulator, and first amplifier were in individual boxes shielded on five sides but opened on the sixth.

Photograph Labelled "Power Tubes":- This is a photograph of one of the power tubes used at Arlington. The photograph was taken on the outside of our building.

Photograph 6905:- This is a laboratory photograph of the same general class of tube as was used at Arlington to show approximate proportions, spacing, plate construction, lead-in wires, and method of spacing plate grid and filaments.

Photograph Labelled "Transmitter":- This photograph shows an ordinary telephone stand on the left with telegraph key, sounder, and clock used to carry on experiments. The telephone is a local phone, the telegraph line is a through circuit to

Mare Island and San Diego. The telephone on the right is the high quality microphone used in practically all the long distance talking tests. The phonograph on the right was used for playing music over the radio circuit during demonstrations.

Photograph 6235:- This photograph shows the oscillator in the top box. The lower box contains the speech amplifier which amplified signals from the incoming telephone line, when necessary.

Photograph 6237:- This photograph shows the modulator in the right-hand lower box and the first amplifier in the other two boxes. The circuits on the output of this amplifier are in the lower part of the lower box. The tubes were in the upper part of the lower box and in the upper box. The tubes in this amplifier were largely unbased tubes. The modulator tube was based. The negative voltage for the modulator and amplifier is supplied by the battery in the lower part of the modulator box.

Photograph 6732:- This photograph shows the power switchboard on the left and parts of the three rows of tube racks.

Photograph 6734:- This photograph shows the front of the first five racks of power tubes, each rack capable of holding 20 unmounted power tubes. Between the first and second rack is a distributing rack in which were located large by-pass condensers, and the chains split across the filaments



- 3 -

to give middle tap connection. This was also a distributing panel for plate leads, filament leads, and grid leads. The bottom of each rack contains a filament switch for the filaments of that rack, a plate switch and circuit breaker for the plate circuit, and a filter in the plate circuit lead.

Photograph 5726-A:- This photograph shows the rear of the first five racks and the front of the second five. Three racks of the second five contain sockets for holding mounted tubes. Otherwise they are similar.

Photographs 5881, 5882, 5819, 5819-A, and the unnumbered one:- These are photographs of various parts of the third group of racks which were constructed with iron frames, micarta panels and glass doors, and hold a total of 300 tubes. A blower for cooling the tubes is on the end.

Photograph 5884:- This photograph shows the antenna tuning coil with the primary coupled to it. Coupling was adjustable by sliding the primary and was operated from below. The tuning coil was in the attic.

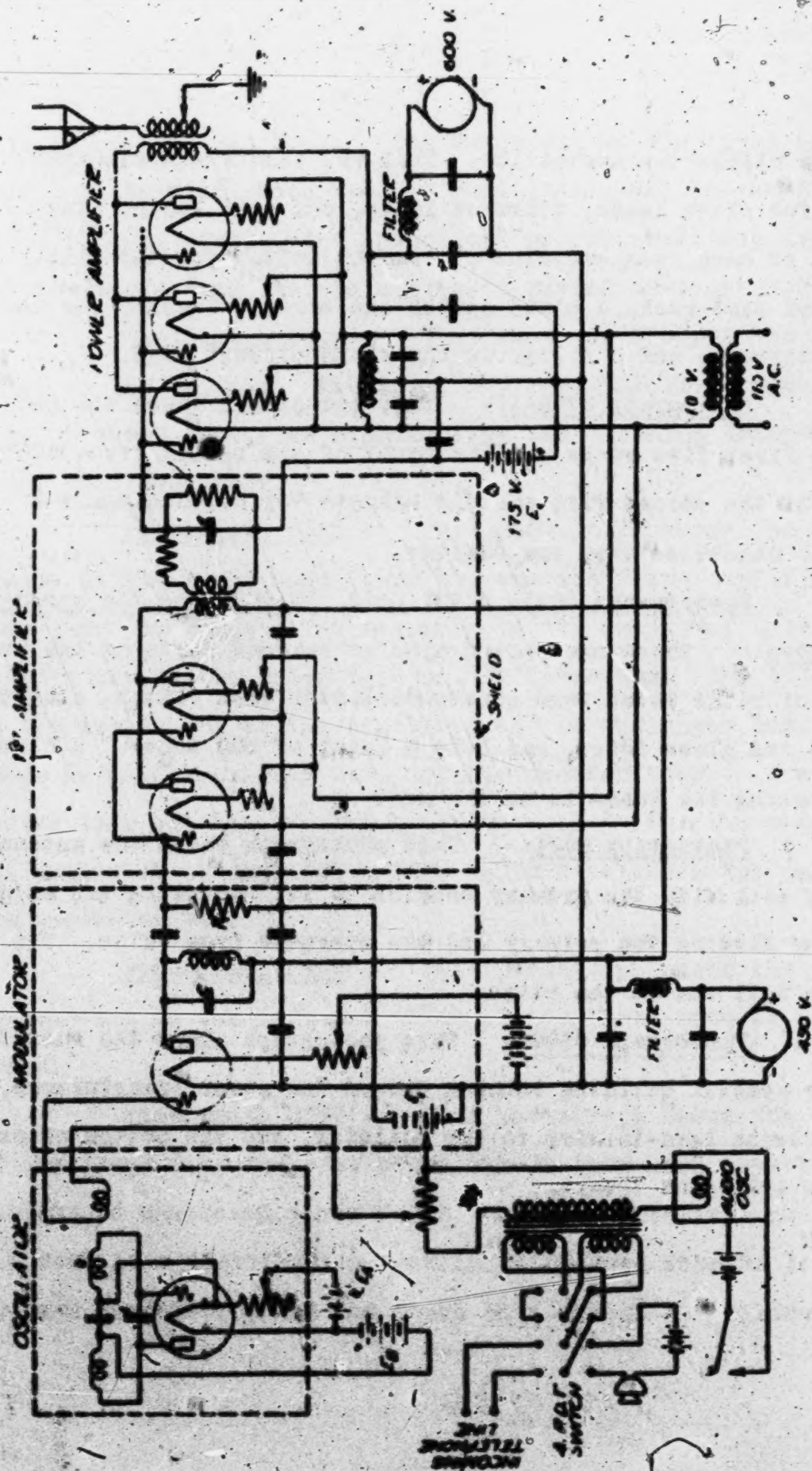
Photograph 5884:- This photograph shows the outside of our special building showing two of our power transformers, the antenna lead-in wire to the building, and the bottom of one of the Arlington towers.

RAH:FM

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RADIO TELEPHONE TRANSMITTER CIRCUIT  
ARLINGTON, W 1915





# POWER TUBES

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TRANSMITTE

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696

OSCILLATOR

SPEECH

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697

# AMPLIFIERS

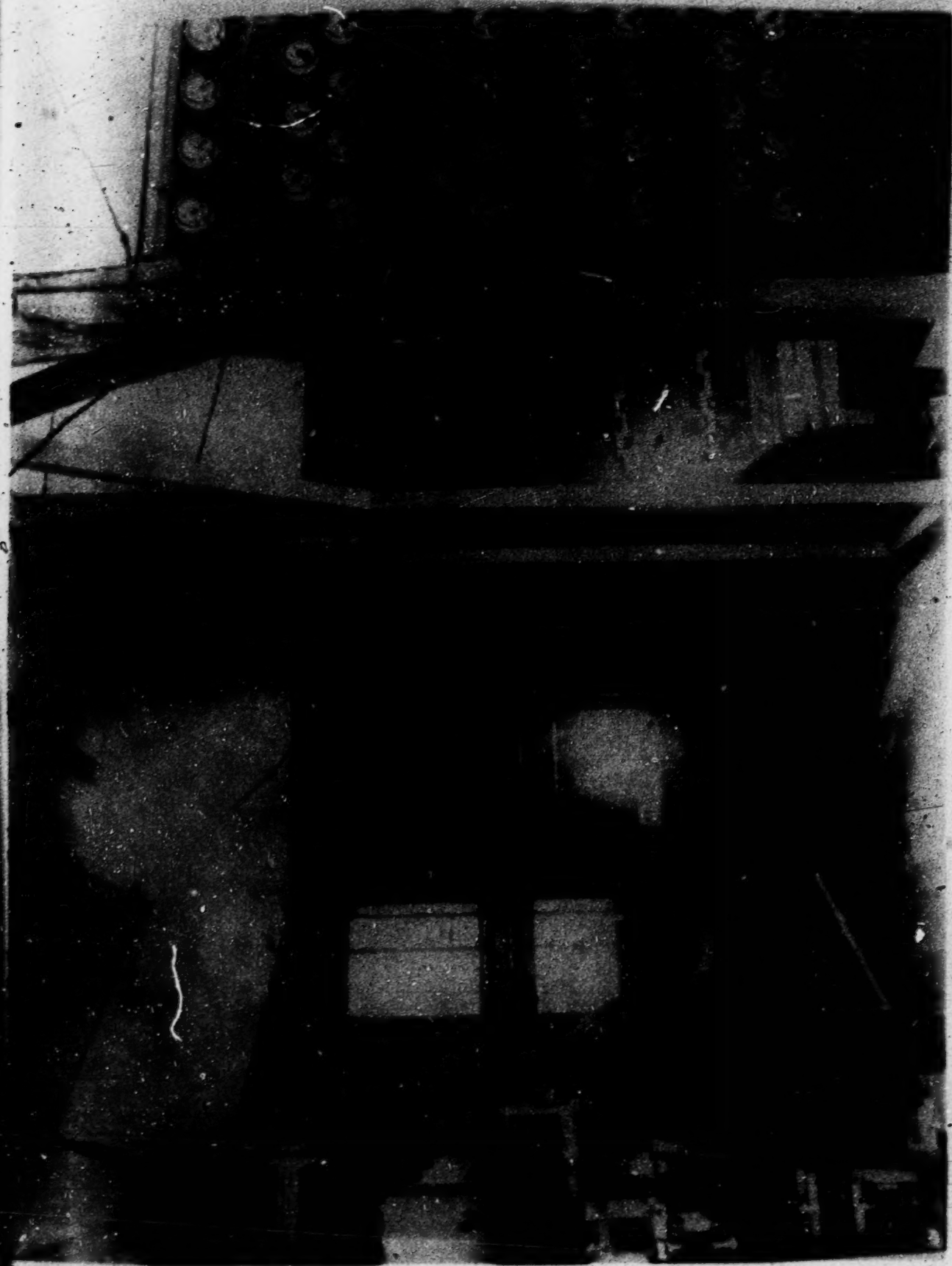
MODULATOR

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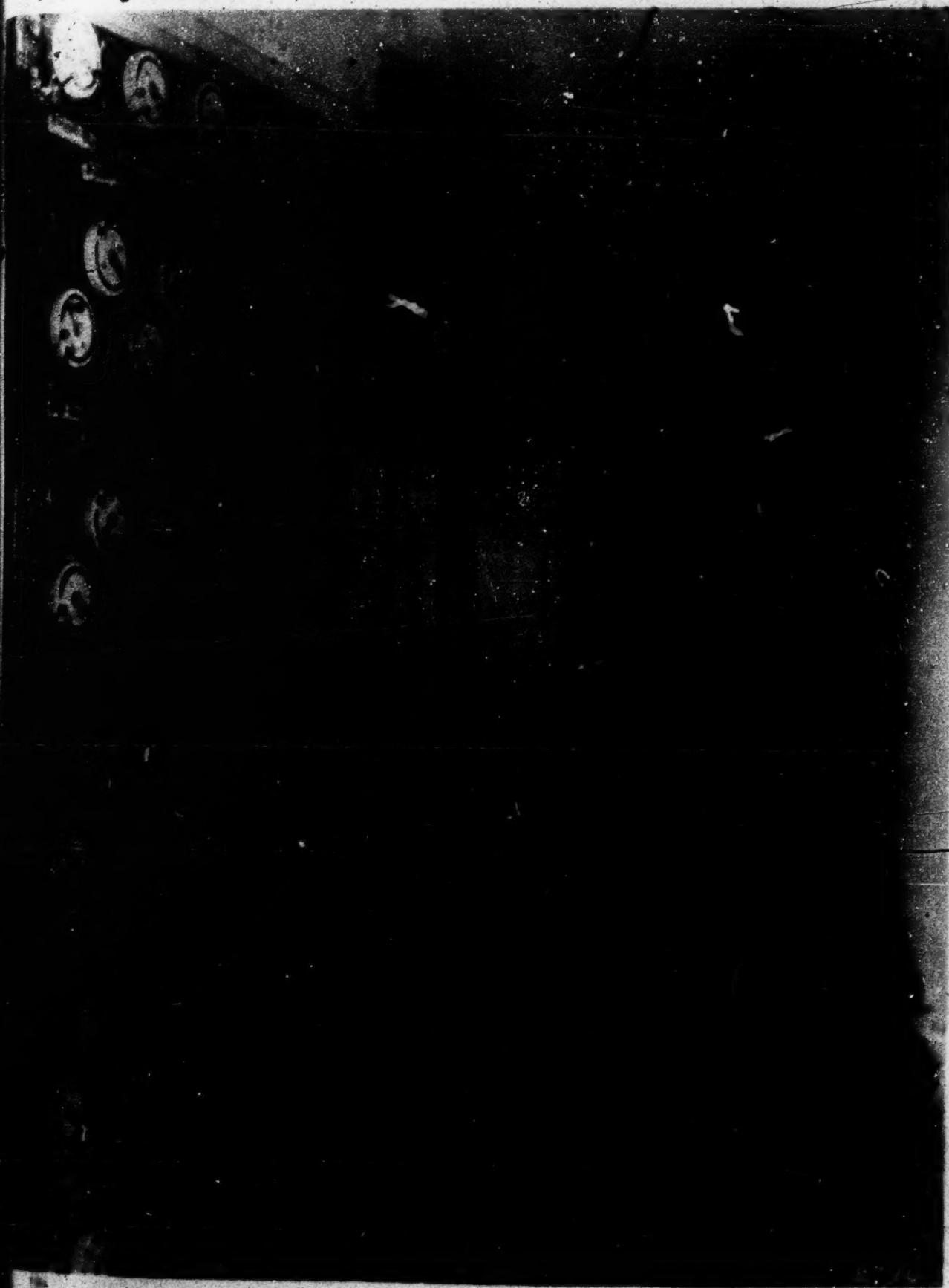
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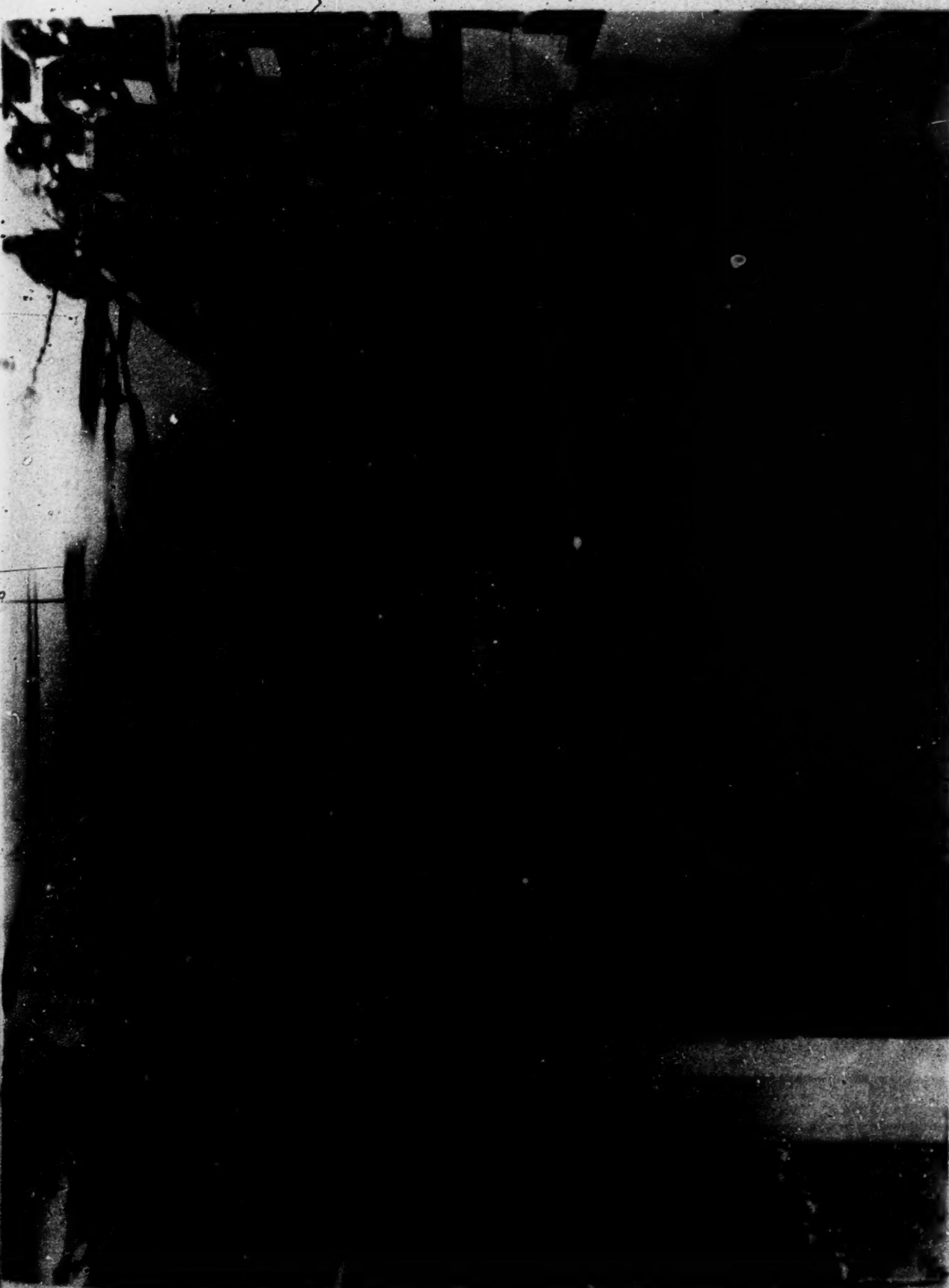


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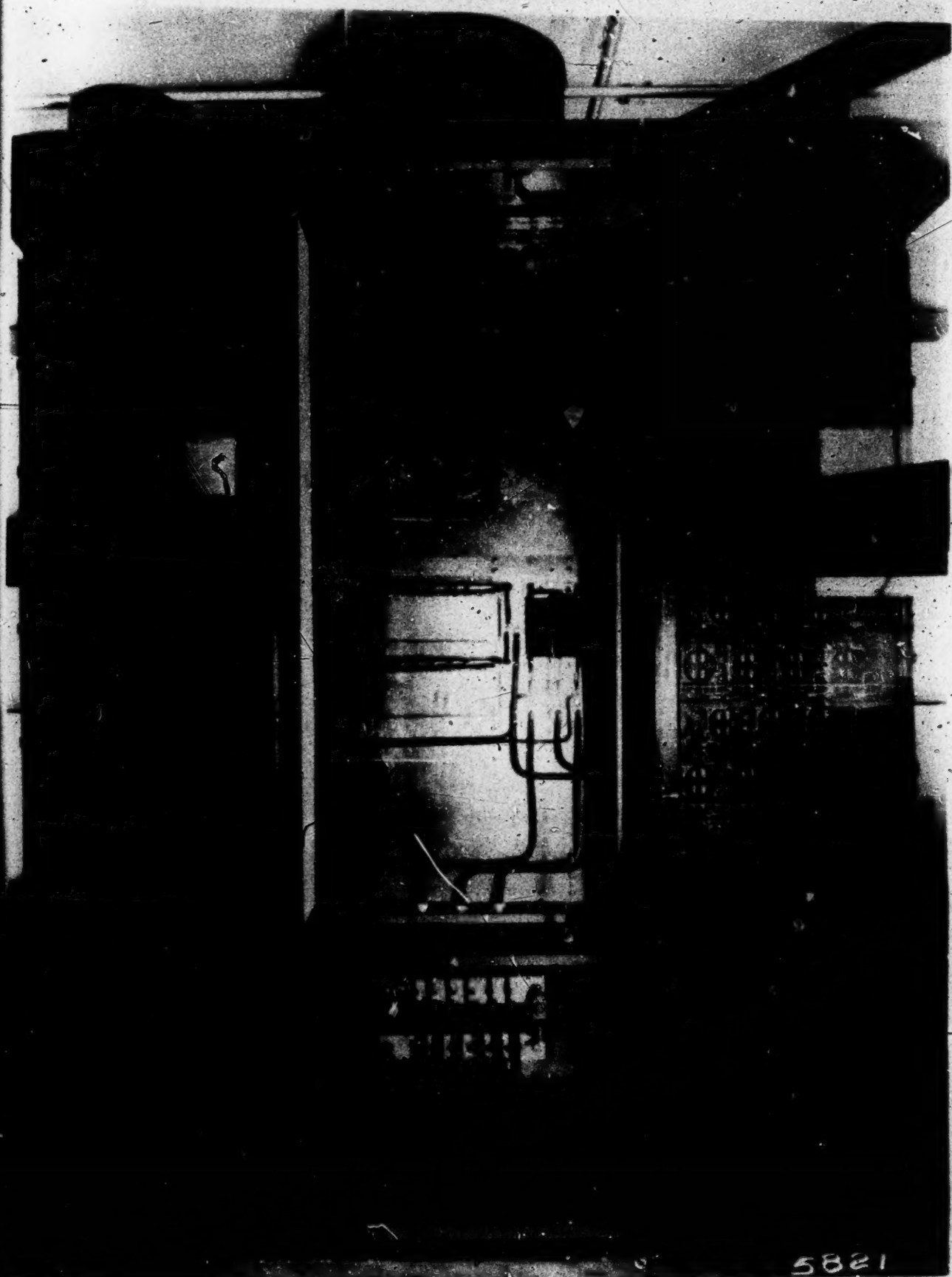


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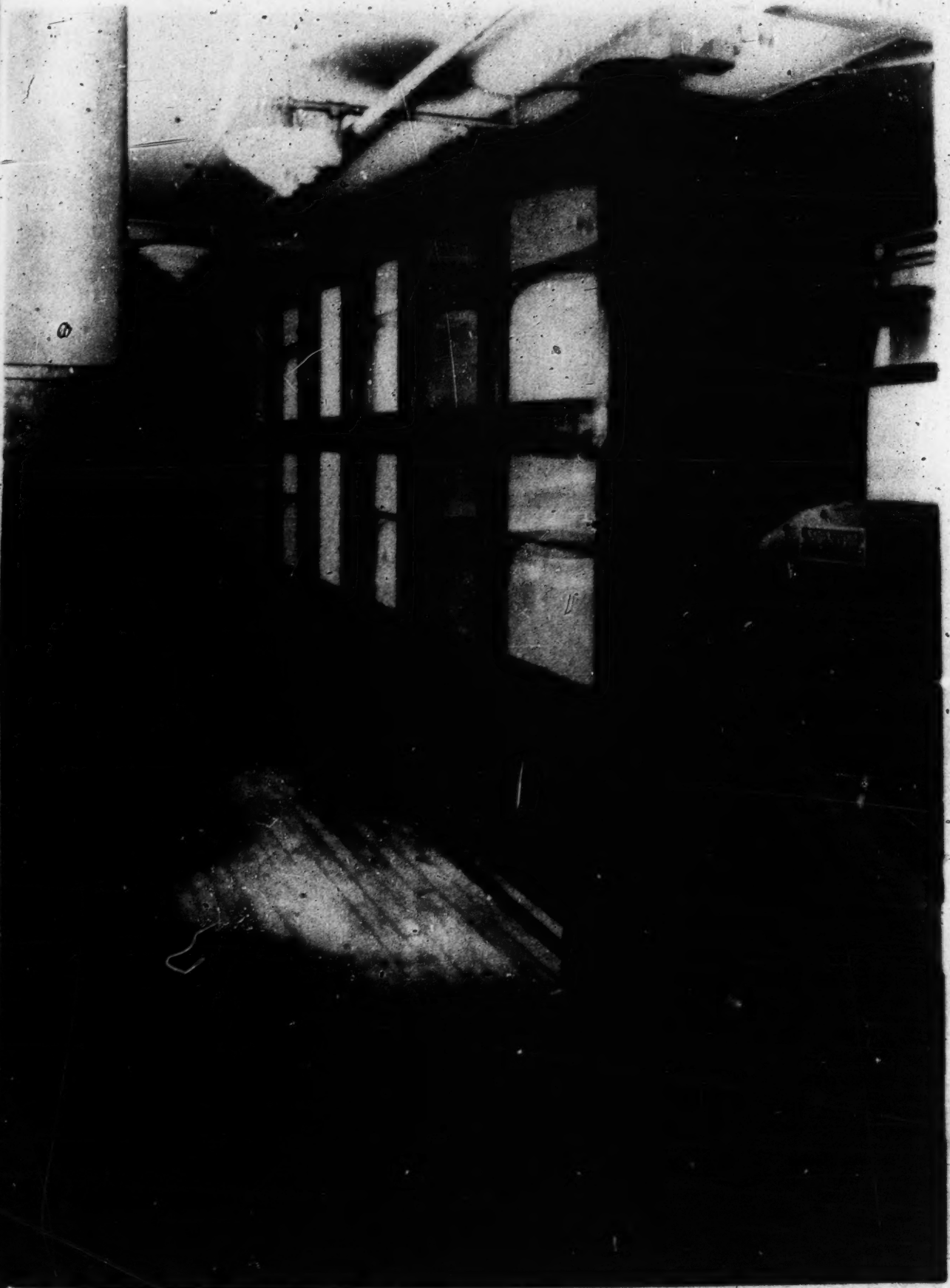


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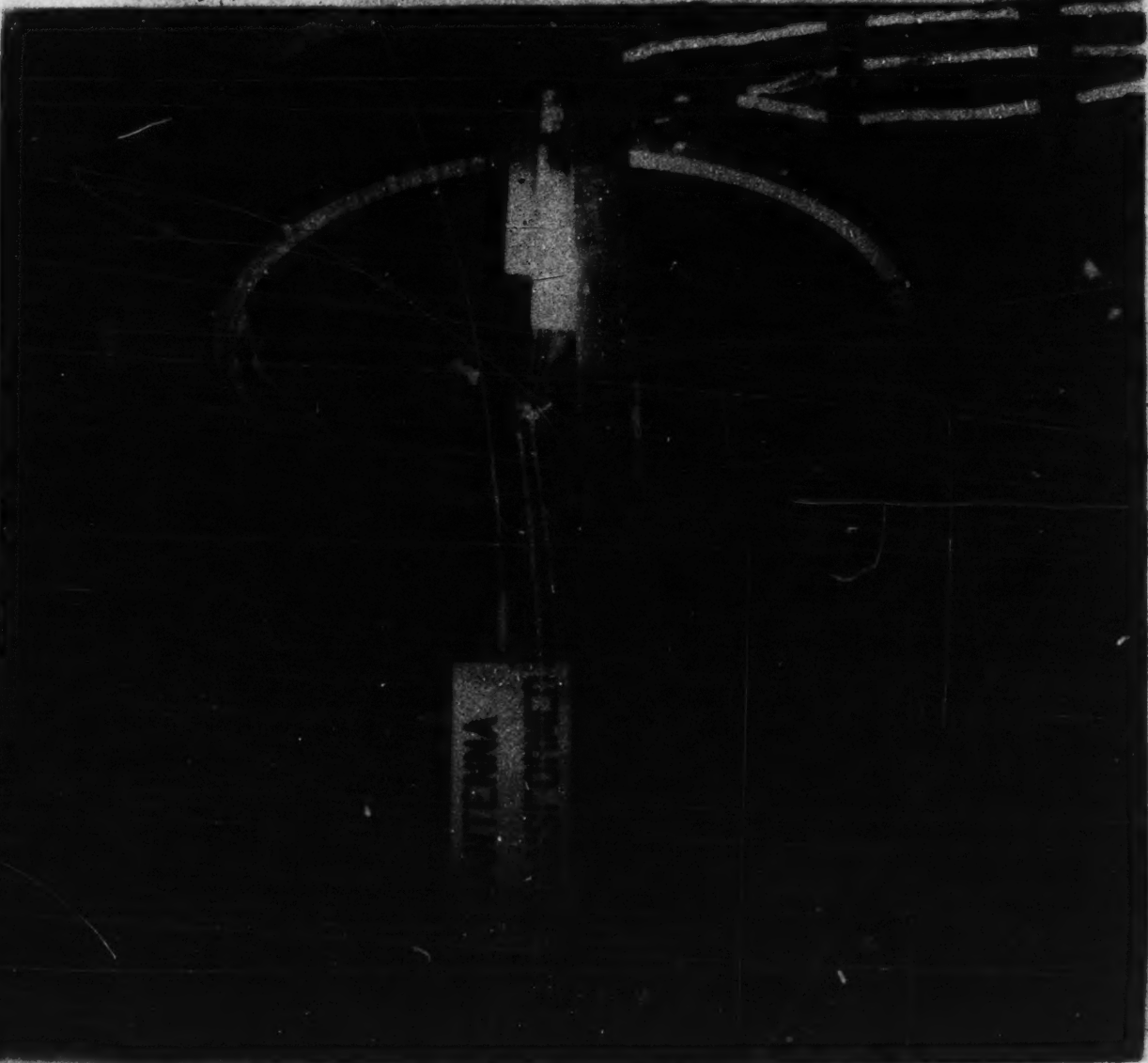
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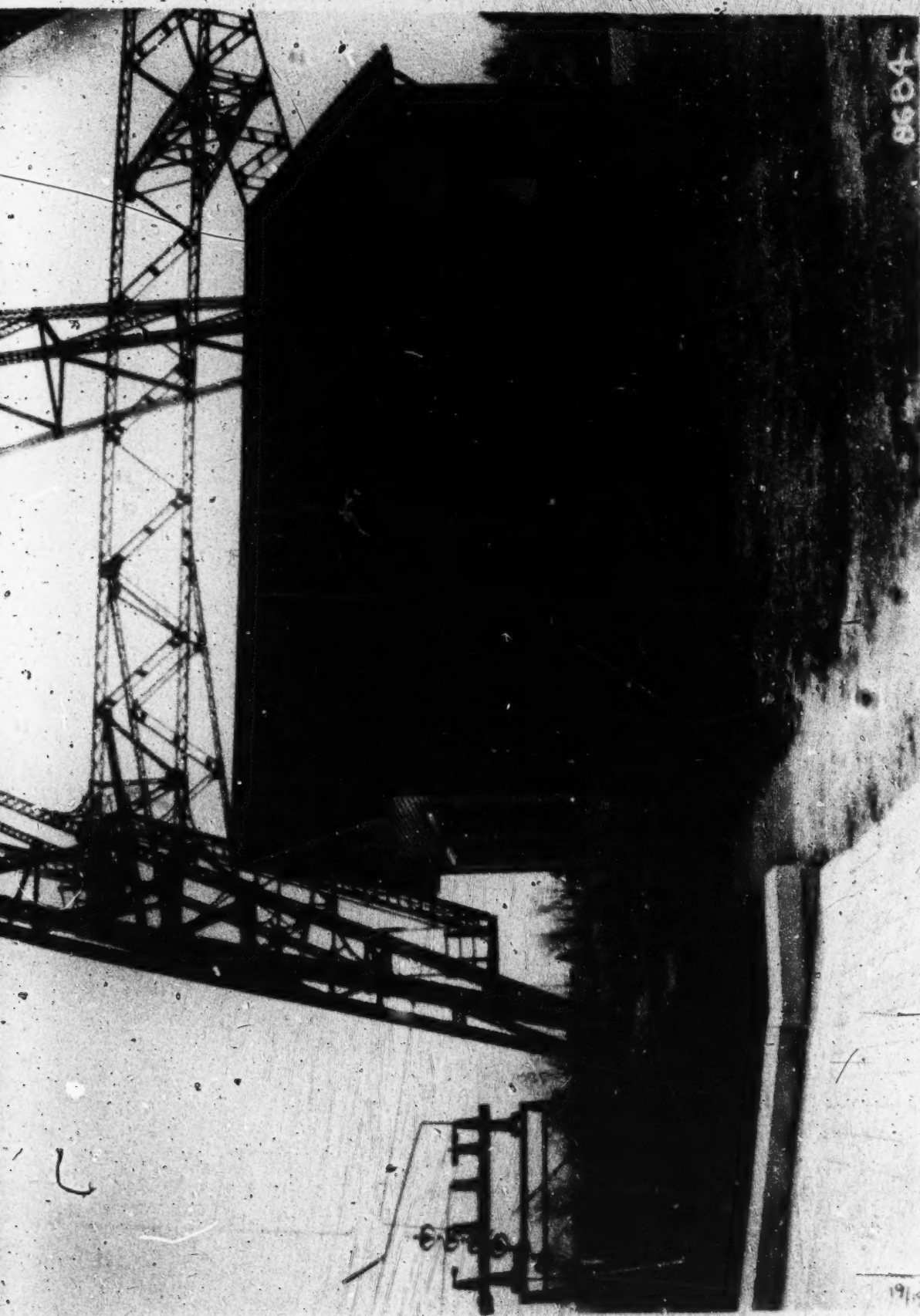


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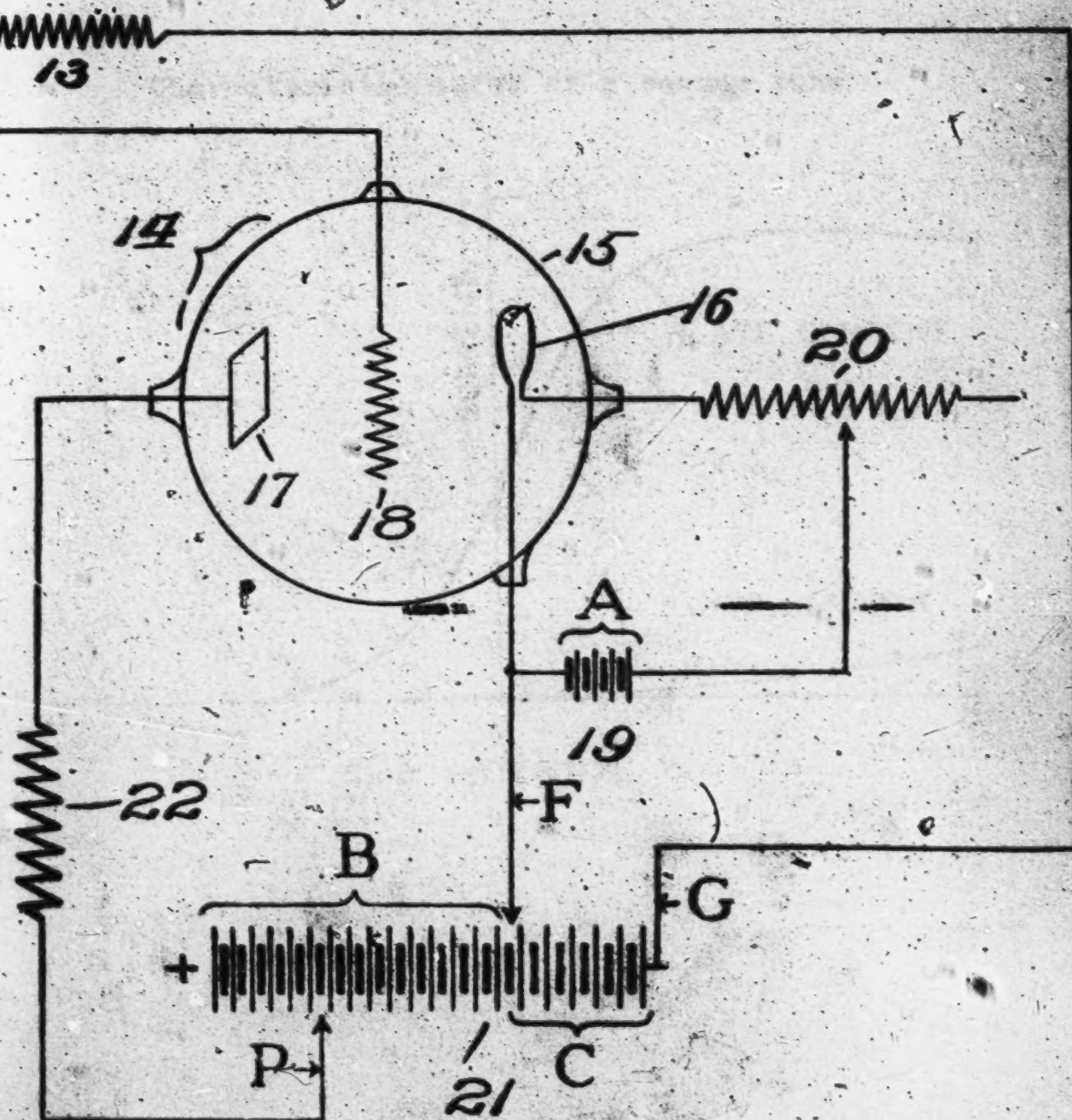
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## PLAINTIFF S' EXHIBIT No. 20

Reproduction of part of the drawing of Lowenstein patent in suit No. 1,231,764, with reference letters added.



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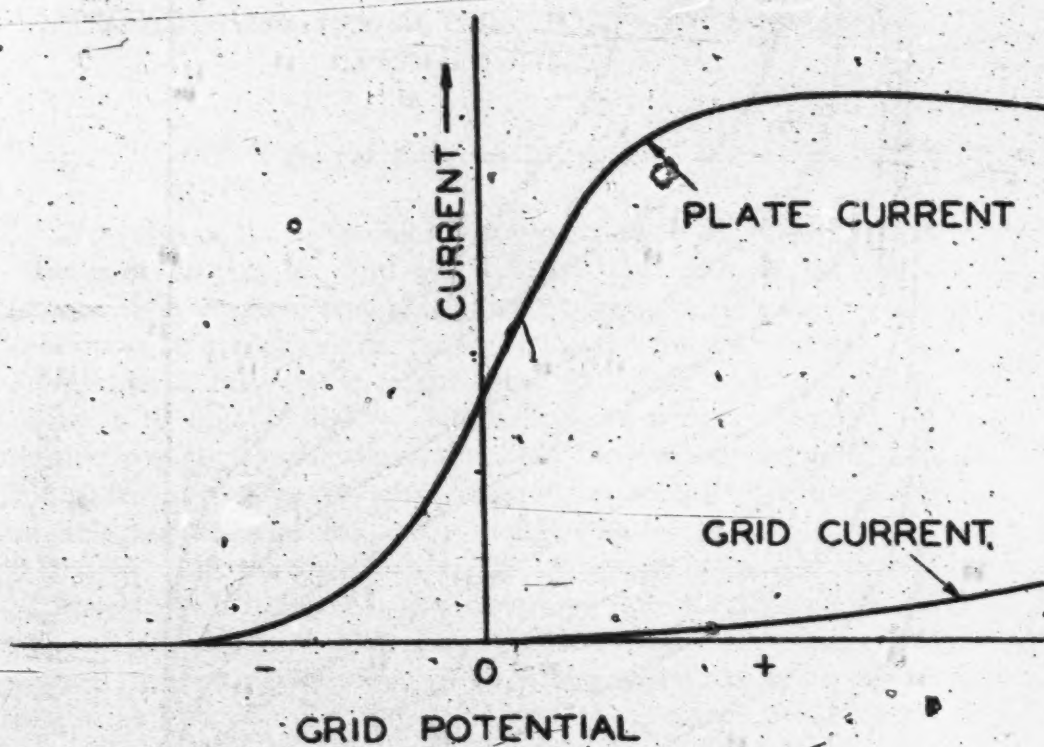
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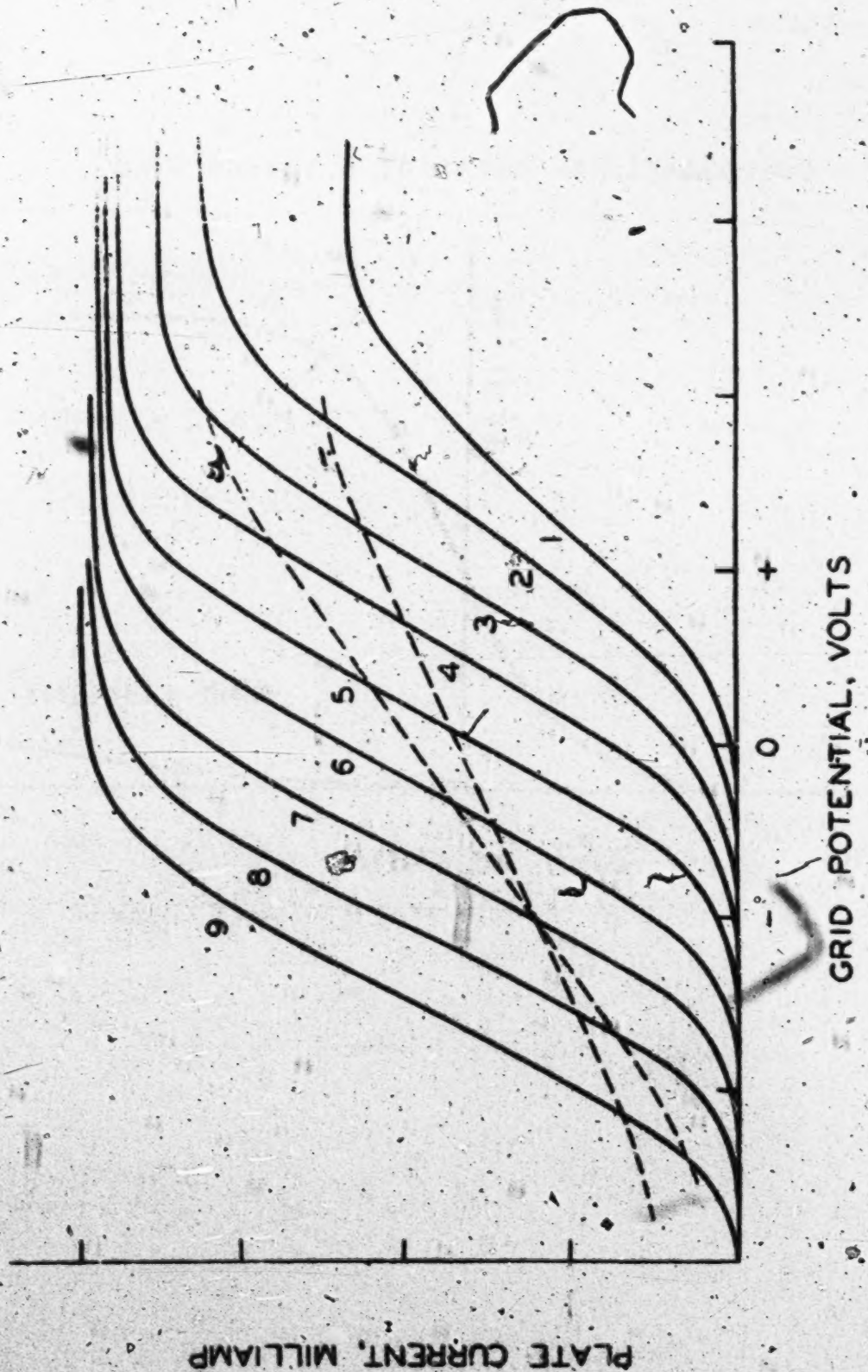


## PLAINTIFF S' EXHIBIT, No. 24

Characteristic curve of a vacuum tube



PLAINTIFF'S EXHIBIT No. 25  
Characteristic curve of a vacuum tube





Article by Lee De Forest in the Journal  
of the Franklin Institute of July, 1920

**Journal**  
**of**  
**The Franklin Institute**  
Devoted to Science and the Mechanic Arts

Vol. 190

JULY, 1920

No. 1

**THE AUDION—ITS ACTION AND SOME RECENT  
APPLICATIONS.\***

BY

LEE DE FOREST, Ph.D., Sc.D.

ANALOGIES are apt to be interesting, and in scientific matters frequently instructive and clarifying. The title of to-night's paper, "The Audion," suggestive of *Sound*, prompts the consideration of an analogy in the realm of *Sight*—the microscope. The audion, in a measure, is to the sense of sound what the microscope is to that of sight. But it is more than a magnifier of minute sounds, electrically translated; the audion magnifies and translates into sensation electric energies whose very existence as well as form and frequency, would but for it remain utterly unknown. As the microscope has opened to man new worlds of revelation, studies of structure and life manifestations of natural processes and chemical reactions whose knowledge has proven of inestimable value through the past three generations, so the audion, like the lens exploring a region of electro-magnetic vibrations but of a very different order of wave-length, has during the scant thirteen years of its history opened fields of research, wrought lines of useful achievement, which may not un-

\* Presented at a joint meeting of the Section of Physics and Chemistry and the Philadelphia Section, American Institute of Electrical Engineers, held Thursday, January 15, 1920.

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VOL. 190, No. 1135—1

audion amplifier, and the scope and value of the new art immeasurably increased thereby. For example, the use of underground receiving antenna, the direction-finder, or radio-compass loop, the elimination of static interference by either of the above, or other methods—all such were compelled to await for their successful application the introduction of the grid electrode. Starting with the small bulb used in 1912-13 as a telephone amplifier and generator of minute electric oscillations for heterodyning purposes, I began the construction of larger sizes to be used in undamped wave transmission. At first spherical bulbs, three or four inches in diameter, and taking 50 watts of plate input energy, were considered large. Such rapid progress was made in improvement of design and construction of these so-called "power tubes," notably by the engineers of the Western Electric Co., that by autumn of 1915 a bank of several hundred tubes, their input and output electrodes connected in parallel, were installed at the Arlington wireless station. By a pyramidal circuit arrangement, whereby one oscillion tube controlled a group in parallel, these in turn controlling larger groups of oscillion tubes, some twelve kilowatts of undamped wave energy was delivered to the great antenna, all perfectly controlled or modulated by an ordinary telephone microphone. By this arrangement the voice was transmitted that year as far as Honolulu and Paris, thus fulfilling predictions made in 1909 to a very skeptical world.

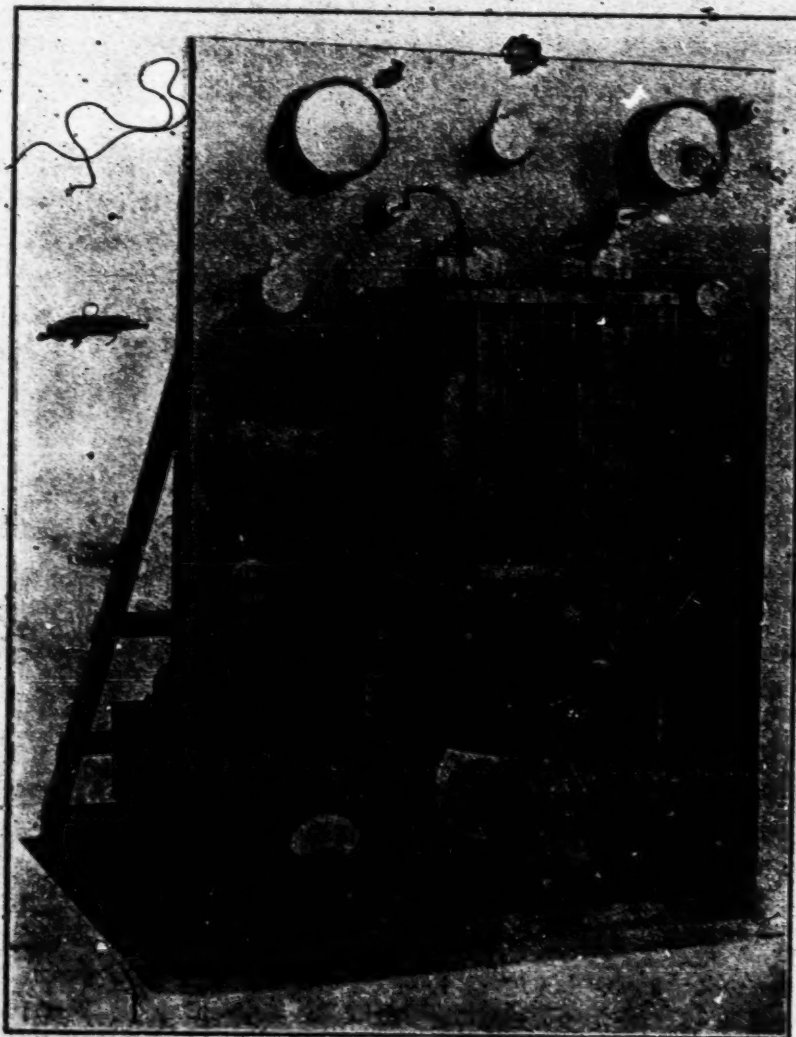
In these Arlington tests the entire system was one of three-electrode tubes—for power generator, for current modulation thereof at the transmitter, and for detector and amplifier at the receiver. More recently Alexanderson, using his powerful high frequency alternator at New Brunswick, has controlled 80 kilowatts of antenna energy by means of his magnetic amplifier. This ingenious development of a Fessenden device was in turn controlled by a bank of large audion amplifier tubes, nicknamed "pilottubes," whereby the original microphone currents were sufficiently amplified to control the saturation currents necessary for the magnetic controlling device.

There are to-day grave differences of opinion among radio engineers as to what type of high-power radio transmitter will prove the key to the future—the high-frequency alternator, the Poulsen arc, or the oscillion. In my own opinion, the long-distance transmission art will shortly depart from true radiation



methods; and the a. c. generator, of comparatively *low* frequency, will be widely used for such subterranean, or submarine transmission, leaving for ship communication only the survival of

FIG. 15.

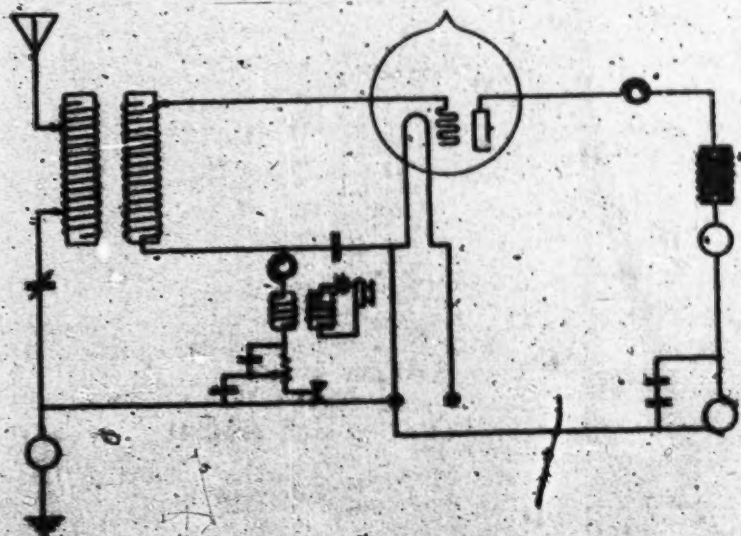


radio transmission, as it is known to-day. Such being the case, we will then have little use for *radio* transmitters of more than 20 to 50 kilowatts. For such transmitters I foresee the early use of a few large oscillion tubes, of say 5 kw. capacity each. Already we are making tubes capable of handling one and two kilowatts, using tungsten filaments and grids, and large anode

plates of tungsten or molybdenum. The efficiency with which several such tubes can operate in parallel, the ease with which an amplified voice current, acting upon their grids, in parallel, can control their combined output make such a system almost ideal as a radio telephone transmitter. A typical oscillion transmitter utilizing two half-kilowatt tubes is illustrated in Fig. 15. The schematic circuit diagram for such a transmitter is shown in Fig. 16.

In the construction of these large tubes a thousand details must be scrupulously observed—in addition to the calculated physical

FIG. 16.



dimensions of the elements, the choice of materials, the method of seal, the preliminary treatment of the metals, their welding, the screening of the glass from bombardment, the various steps in the process of exhaustion—on careful observance of all these along depends success in the manufacture of a high-power tube. A reasonably long life, of 500 to 1000 hours, is afforded by the tungsten filament, pure or alloyed with thorium; but this is by no means an ideal source of electrons. As such, tungsten, while preferable, is highly inefficient. By coating fine platinum ribbon with oxides of calcium, strontium, etc., or of the rare earths, similar to those in the Nernst glower, far higher emission efficiency is had, at lower temperatures, with resultant increase in life. But such oxide-coated filaments are fragile and very fre-



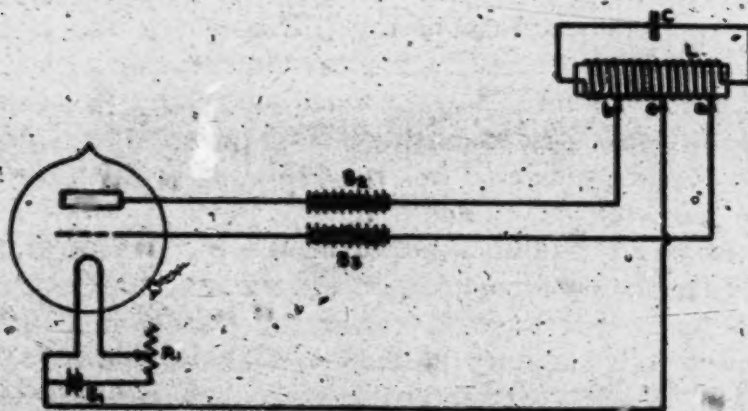
quently damaged during exhaust. Moreover, many types of coating lose their power of electron emission after a time. This method seems at best an imperfect makeshift. What the audion art awaits is a ribbon filament of some new, well-conducting alloy, wire drawn or rolled, of non-crystalline structure, emitting floods of electrons at a heat even lower than visibility. Reward awaits the metallurgist who first produces such a filament. For to-day the audion is being produced in quantities which in pre-war days would have been considered fantastic exaggeration. During the last months of the war the world production of such bulbs had attained the incredible rate of 1,000,000 per annum. And now the demand in America alone, chiefly from radio amateurs and experimenters, is at the rate of some 5000 per month, and constantly growing. And most of these latter are used singly or in two-step amplifier arrangements. During the war, however, thousands of amplifier and transmitter instruments, each requiring 3 to 9 bulbs, were in use—in earth telegraphy, in submarine listening, in telegraphy by ultra-violet or infra-red rays, in gun-spotting, airplane detection, etc., in addition to those required for ordinary radio telegraphy and telephony.

The necessary conditions for an audion to function as a generator of alternating currents have been the subject of exhaustive study by many investigators, notably by Hazeltine, Ballantine, and Mills in this country; Vallauri and Eccles abroad. There are to-day countless circuit arrangements whereby the audion may be caused to generate such currents; but in all of the practically useful ones, where considerable power is required, the inductive linking of the grid and plate circuits, analogous to that first used in 1912, is in one form or another employed. One of the simplest forms of such circuit is shown in Fig. 17. If there is no time lag in the electronic stream behind the pulsations of grid voltage, as is the case in a highly exhausted tube (up to frequencies of ten million per second), then the above arrangement becomes an alternating current source whose frequency depends upon the natural frequency in the  $LC$  circuit. The period of this oscillation is very nearly  $2\pi\sqrt{LC}$  if the resistance,  $r$ , of the external plate circuit is small, the resistance, or reactance,  $p$ , of the plate-filament gap is great, and provided the mutual induction,  $m$ , between the inductances in the grid-filament and plate-filament circuits is just sufficient to maintain the oscillations.

If, then,  $m > \frac{1}{k} \left( \frac{L}{p} + r.C \right)$  this oscillating condition is realized; and  $K$  in this formula can be defined as the "amplification factor."

One of the latest developments in the oscillion transmitter is the application of alternating current for the plate voltage supply. Sixty cycle current is taken from a lamp socket, stepped up to 500 or 10,000 volts (according to the size of the transmitter)—the two halves of the cycle rectified through two-electrode vacuum valves, this rectified current stored in a suitable condenser, smoothed out by an appropriate "filter" circuit, and finally delivered as high-voltage direct current to the plate-filament circuit of three-electrode oscillator tubes. The filaments of both recti-

FIG. 17.



fiers and oscillators are lighted from the low-voltage windings on the one transformer. Such an arrangement does away with the motor generator converter, and even with 60 cycle supply gives surprisingly clear voice transmission. A small set of this type employing two rectifier and four small oscillating audions in multiple is shown in Fig. 18. With this small unit, consuming 50 watts and putting three-quarters of an ampere in an average antenna, one has recently telephoned fifty miles.

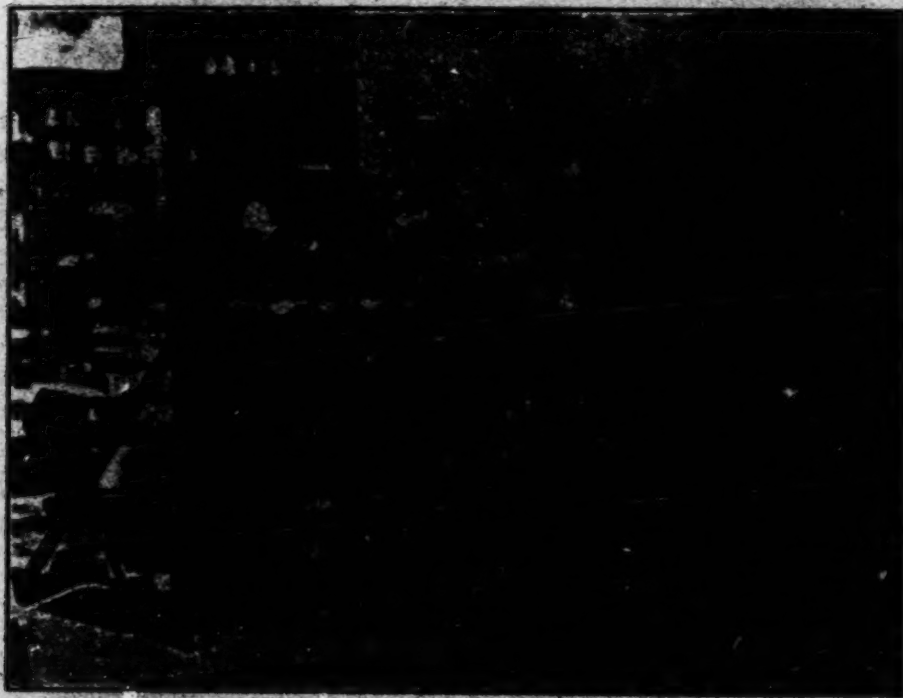
The developments by the engineering staff of the Western Electric Company of the audion amplifier as a telephone repeater, since my first demonstration to them of its possibilities in that field, are beyond all praise. The real and rare understanding of the elements of the problem with which this staff of trained men developed the amplifier and applied it to the long-sought trans-



continental telephone line stand unique in the annals of brilliant achievement in electrical engineering.

The time was ripe. Had the audion amplifier been presented at a much earlier date it is unlikely it would have then met the warm welcome which twenty years of futile search for the telephone repeater had earned for it. It was the irony of inventive fate that this revolutionary telephone device was to come, not

FIG. 18.



from those whose efforts had for years spun in the old rut of the receiver-microphone "siameesed" together, but from an art younger than telephony, from a device conceived for a quite different application—a wireless telegraph detector.

"From small beginnings the transcontinental line has been evolved. One element after another came. First the telephone receiver of Bell; then the Berliner—Edison microphone; then adequate line construction; the Pupin coil to prevent voice distortion—and finally the one missing link, the Audion Amplifier. Try to imagine one of the electronic carriers of the voice currents in this amplifier, and contrast it with a carbon granule of

a microphone transmitter of the early telephone relays. Compare a soap bubble with a load of coal, and you will have some relative idea of the distinction between the delicacy and elegance of the audion and that of the old microphonic relay." A more revolutionary step was never taken in the history of electrical engineering.

A repeater suitable for our present wire telephone system should supply energy amplification sufficient to restore the attenuation produced by twenty miles of standard cable. This actually means that the repeater must be capable of delivering 256 times as much energy as it receives; that is, possess a telephone efficiency of some 26,000 per cent., and this without appreciable distortion of the most intricate of voice current waves, involving all frequencies from 100 to 3000 per second. Any repeater or amplifier which produces distortion of the speech currents is to that extent unfitted for use in tandem operation, because the distortion is cumulative in the successive repeaters; and mechanical amplifiers generally, and even the best of that type, produce distortion.

A large amount of unnecessary secretiveness or mystery was for some time thrown around the type of telephone repeater which made possible transcontinental telephony.

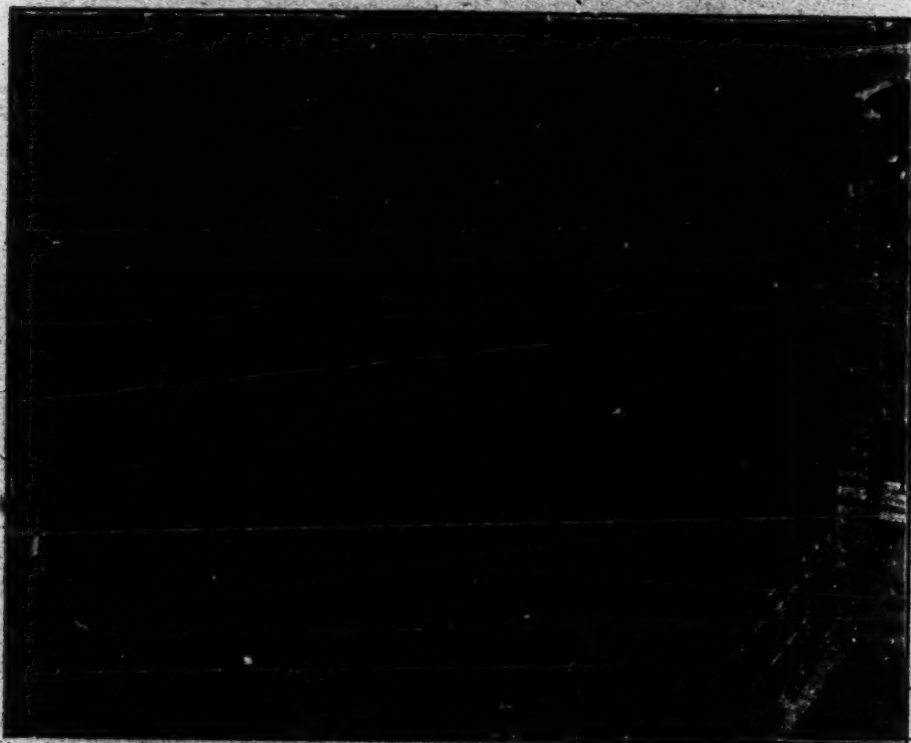
A well-known telephone engineer has recently stated that the audion amplifiers used by the American Telephone and Telegraph Company are practically distortionless, and are commercially used in tandem operation in regular installations, and were so used in the first transcontinental line, which would have been impossible without the use of the tandem arrangement. By actual trial over cable circuits approximately one thousand miles in length it has been found that as many as thirty of these audion amplifiers can be connected in tandem and produce excellent speech at the receiving end of the line. This engineer is authority for the statement that computation shows the attenuation of a cable circuit of this length to be so enormous that if all the power received on the earth from the sun could be applied in the form of telephone waves to one end of the line, without destruction of the apparatus, the energy received at the other end would be insufficient to produce audible speech without the use of amplifiers; whereas with 30 amplifiers used in tandem the relatively minute energy of ordinary telephone speech currents at the transmitting



end produced speech in the receiver at the opposite end which was both loud and clear, the amplification due to such a tandem arrangement of tubes being of the order of  $10^{10}$ .

The audion which has been evolved to meet these requirements, most rigorous of all its numerous applications, differs in many details from the detector or the oscillating audion. The presence here of gas ionization sufficient to cause appreciable dis-

FIG. 19.



tortion cannot be tolerated, neither must the grid be permitted to be positive at any phase of the cycle of impressed voltage. A hundred other minor requirements, small yet difficult of realization, have been patiently achieved by our telephone engineers, who now state that "the amount by which it (the audion amplifier) fails to meet all the requirements for a perfect repeater is so small as to be negligible except under the most rigorous conditions."

The illustration (Fig. 19) conveys a more vivid idea than any description of the thorough completeness with which the

American Telegraph and Telephone engineers have applied the audion repeater to the commercial long-distance telephone service. It illustrates a typical group of repeater racks, each rack carrying two complete repeaters. This view was taken at one of the main repeater stations on the Boston-Washington underground cable line, located at Princeton, N. J.

FIG. 20.



Two-stage audion amplifier.

Popular attention has been attracted to the success of the recently announced application to line wires of wireless methods of transmission, reception and tuning, whereby multiplex telegraphy and telephony have been made possible over wires already loaded down with their ordinary communication. The original ideas of such multiplex telephony date back to the early nineties, when John Stone Stone, Hutin and Leblanc disclosed methods all involving the same principle, that several alternating currents of



superaudio-frequency, each from a separate source, could be directed over the same wire or pair of wires, each be modulated or controlled by its own microphone, or Morse key, and at the receiving station each frequency taken off by its own properly tuned circuit, and there retransformed into its own original telephone or telegraph current. But none of these early investigators utilized at that time the all-necessary integrating detector which

FIG. 21.



50-Watt amplifier.

was alone capable of retransforming the modulated high-frequency wave-trains back into their original audio-frequency currents. Here again the wire telephone requirements had to await the advent of a radio-detector.

General (then Captain) George O. Squier in 1910 carried out certain experiments which are destined to become classic as the new art of wired-wireless attains the important commercial proportions to which it is unquestionably destined. He, for the first time, used a constant, reliable source of undamped electric

currents of high frequency for the transmitter, and an audion detector between each tuned receiving circuit and its telephone receiver. By this combination multiplex telephony became at once a realized fact.

But so long as a high-frequency alternator was required at each transmitter station the wired-wireless idea could not become commercialized. Its first cost, the size and weight of it with its motor, its delicacy of speed regulation, its limitation to relatively low frequencies, all made this impossible. So again an important development was compelled to await the advent of the oscillating audion.

Supplied from a common filament-lighting battery, a common "B" battery, or d. c. generator, any desired number of tiny alternating current generators, each driving its own easily tuned circuit, can now be assembled in a small central station. The grid of each oscillator is voice-controlled from its local telephone circuit, and as many high-frequency "carrier" wave-trains superimposed upon a single trunk line pair, as it may be feasible to use without interferences between the modulated frequencies of the several conversations.

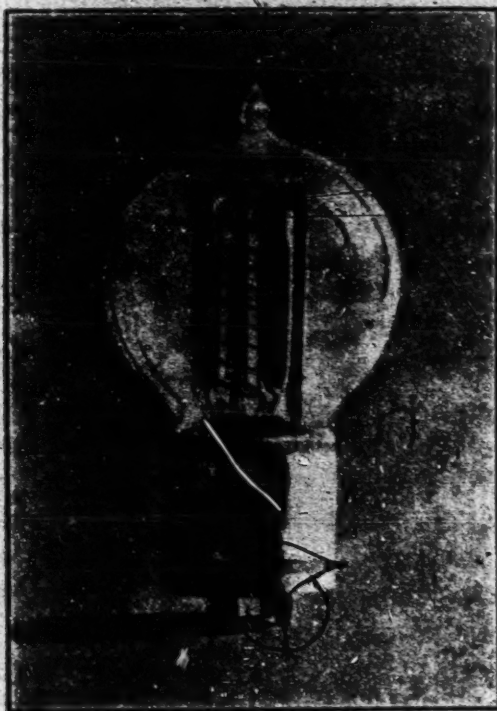
At present carrier frequencies ranging from 5000 to 25,000 have been used commercially over a single pair of telephone wires, between Baltimore and Pittsburgh. A zone of frequencies of 2500 is allotted to each conversation, which permits of eight simultaneous telephone conversations over the line, in addition to the usual "physical circuit" conversations. The constant frequency generated by each individual oscillation lies in the middle of each allotted zone of wave-frequencies, but the modulation of this "carrier wave" by the voice currents results in a wide band of frequencies (analogous to a spectrum band) on each side of the particular carrier-wave frequency. This means that at the receiving station it is preferable to employ, instead of a circuit attuned to the single frequency of the carrier-wave, a "band-filter," or combination of several tuning elements (inductance and capacity). This band-filter, then, is equally receptive to any wave-frequency lying within the prescribed limits, say 1,250 cycles on each side of the carrier-frequency, but offers very high impedance to all frequencies above or below the limits of the band-frequencies. By eight such band-filter receiving circuits the eight conversations are segregated, each delivered to its own



proper audion detector and sent out on its own local telephone line.

But it is by no means necessary to limit wired-wireless to the use of such low frequencies as we have been considering. Certain tests were recently carried out in Canada which proved conclusively that frequencies as high as 500,000 per second can be used over telephone lines, including several miles of cable, without harmful attenuation. This demonstration widens very

FIG. 22.



Western electric audion amplifier.

greatly the range of frequencies available for wired-wireless, with hope for a corresponding increase in the number of conversations, or telegraph communications, which can be placed upon a single pair of wires, or group of pairs. Moreover, with such high frequencies (say from 100,000 to 300,000 per second) the necessity for complicated band-filter receiving circuits vanishes, with obvious attendant advantages.

Wired-wireless is the youngest of the large family of methods for electrical communication of intelligence. He is indeed a

bold prophet who will to-day attempt to foretell the limits of its application. That the great saving in line costs, the vast multiplication of available channels of long distance communication which it makes possible will work profound changes in our present methods of business, cannot be questioned. Thus again it seems evident that the audion is destined to play a leading rôle in the work of knitting more closely the people of this land, and of all lands.

We have briefly recounted some of the main achievements which the three-electrode audion, or triode, has to its credit. Let us now consider some of the possibilities of its future. From its invention until 1912 it attracted an almost negligible interest in the scientific world. A year after the audion was first brought to the attention of the engineers of the American Telegraph and Telephone Company that corporation acquired exclusive license under all the audion patents for wire telephone purposes. Thereupon the research men of that organization initiated an elaborate line of investigation of the device, which about that time began to interest other scientists in America and abroad. Prior to 1914 not a dozen articles on the audion had appeared in scientific publications. To-day it is impossible to pick up a magazine directed to physics or electric communication without finding one or several papers dealing with some of what Dr. Eccles styles "the protean properties of the ubiquitous three-electrode tube."

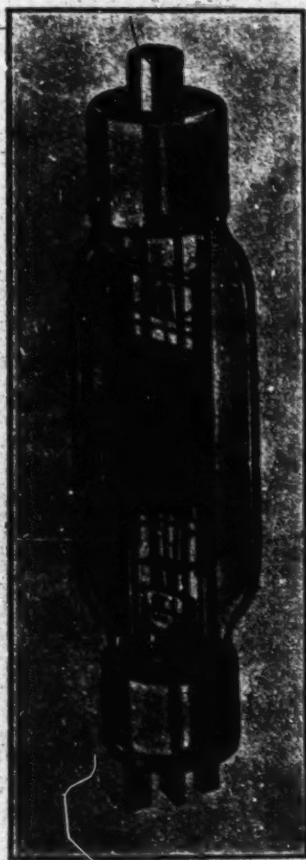
Writing in the *Radio Review*, Dr. Eccles (who is affiliated with the British Marconi Co.) says: "The most important single instrument in modern wireless practice is the three-electrode thermionic vacuum valve, for it enters into every main division of the subject—it plays a dominant part in the generation of oscillations, the detections of signals, and in the amplification of feeble voltages and currents. Its arrival and development have, besides, helped greatly towards the success of apparatus and methods that might otherwise have remained almost failures."

Dr. Eccles has outlined the present status and forecast of the future of the audion so clearly that I am constrained to quote further his words, as those of an unbiased observer: "During the war, hints reached the civilian that a revolution was taking place in wireless telegraphy, the principal agent in which was reported to be an instrument called a 'valve,' a 'lamp,' or a 'tube.' This instrument seemed to have arisen suddenly into a predomi-



nant position among all the apparatus of the wireless experimenter and operator, and appeared to be of use in every corner of his outfit. The complete name of the instrument is the three-electrode thermionic vacuum tube. It must be emphasized that it is the three-electrode valve, and not the valve with two electrodes, that has been responsible for the overthrowing of the old

FIG. 23.



1 Kw oscillion.

methods and apparatus. That it has been a veritable revolution can be seen by comparing the common practice in wireless telegraphy of 1914 with that of 1919. In 1914 practically all the most powerful transmitting stations in the world generated waves by sparks and signals were received at nearly all stations by means of crystal or magnetic detectors. The spark method of generating waves involved the use of very large an-

tennæ for spanning great distances; and at the receiving stations which wished to listen to stations more than even 100 miles away very large aerial structures were customary. But if we look at the state of affairs to-day we find most of the high-power stations for long-distance transmission are 'continuous wave' stations; that is, they produce uniform uninterrupted waves instead of a series of short gushes made by sparks; while at the receiving end new modes of detecting these continuous waves appropriate to, and taking advantage of, their uniformity in character have been introduced. This is where the three-electrode tube, in various adaptations, enters the arena. Taken together, the improvements at both ends of the span have made possible the use of smaller antennæ at transmitting stations, and have almost removed the necessity for any antenna at all at receiving stations. For example, under reasonable weather conditions, it is quite easy to listen to the messages coming from stations on the other side of the Atlantic by using a receiving circuit of which the receptive element is a small coil of wire, three to four feet square. Thus, so far as receiving goes, it is possible to intercept all the great stations on one-half of the globe by means of apparatus contained wholly in one room, or even in a cupboard. In accomplishing this the magnifications in use amount to several hundred-thousand-fold. All this is the work of a thing which looks like an ordinary electric-light bulb with a few extra pieces of metal in it—the three-electrode tube."

Years ago what physicist did not look at the simple, self-contained, noiseless incandescent lamp, consider it as an ideal source of electro-magnetic waves of a wide spectrum—of heat, visible, and ultra-violet radiation, and wonder why it should not be made to generate also waves of any length? To-day that incandescent lamp, with the addition of a metal plate and wire grid, has become such a generator. Undamped Hertzian radiations of a few centimetres' wavelength can be generated by audions specially designed to give minimum capacity between the three-electrodes and their lead-in wires. From these short waves, representing alternating current frequencies of some hundreds of millions, down to those of one or two per second, the electric-wave spectrum afforded by the oscillating audion is continuous. Consider this fact in connection with the almost infinite sensitivity of the device as a detector, and its unlimited power as a magnifier,



or amplifier, and one realizes something of the value of the three-electrode vacuum tube to the physicist and the inventor. To the former, however, the keenest interest lies perhaps in the audion itself, because there is no known piece of electrical apparatus linked so directly with the most recent work on the structure

FIG. 24.



"VT-21" signal corps audion.

of matter. A prominent British physicist has recently remarked: "It is probable that there is no other sphere where research work has had such a combination of immediate practical value and intense theoretical interest."

Many an early experiment in telegraph transmission or reception by wire or wireless, long since abandoned as too limited in

range, can to-day be revived to the great benefit of man. Calculations have shown that with a littoral cable stretched for 50 miles on each side of the Atlantic, and carrying some forty amperes of 20-cycle alternating current, telegraphic communication by conduction or leakage currents should be possible, using the audion

FIG. 25.



14-Kw oscillation tube.

as detector and amplifier. I venture to prophesy that within a few years the tall towers and the atmospheric disturbances, which have for two decades been esteemed necessary evils in trans-oceanic wireless signalling, will be regarded with those sentiments which we now bestow upon the coherer and the spark.

But more than this. Signalling by conduction currents of relatively low frequency will soon be practiced through the earth as well as water; and we will find the antennae of the future thrust



upside down, as into abandoned oil-well borings, and making contact with deep semi-conducting strata, at points separated by a few miles; the two inverted antennæ of such a transmitter connected by an overhead power transmission line containing the alternating current generator and signalling device; and a similar arrangement for receiving. Then our wireless messages will go through the earth's crust, or possibly by a more direct path; and not around the earth's surface, to be tangled up as at present with a bewildering snarl of static ravellings. The audion amplifier stands ready to lead us back to the simpler methods of Morse and Lindsay, meritorious methods long ago abandoned because of the lack of an electric ear of indefinitely great sensitiveness.

The future of radio signalling at sea lies with the telephone rather than the telegraph. The simplicity, the reliability with which the medium of an undamped wave-carrier, ideally suited for voice transmission, can now be had will rapidly limit the crudity and laboriousness of the Morse code signalling between ships. Yet to-day scarcely the dawn of this new epoch has been seen. Vessel owners are to-day almost as skeptical regarding the practicability and utility of the radiophone as we pioneers found them towards the wireless telegraph sixteen years ago!

In the future during fogs at sea a short-wave radio telephone will be used to prevent collisions, distances being determined (as well as direction) by conversation, whistled signal or bell, and a calibrated stop-watch. This service will be quite independent of the long-range wireless signalling. The new radio has also a wide field of usefulness in telephoning between islands, thousands of which will never be linked by cable. Other useful fields await in sparsely peopled countries, between mines, oil wells, forest patrols, from express trains, etc. The future of aviation will be found linked with radio telephone, for a score of different purposes. Telephony by audion transmitter, receiver, and amplifier not only carries the complexes of human speech without distortion, but delivers them where human speech itself is impossible otherwise—amid the deafening motor and propeller noises of the airplane, from one to five miles above the earth.

Little imagination is required to depict new developments in radio telephone communication, all of which have lain fallow heretofore awaiting a simple lamp by which one can speak instead of read.

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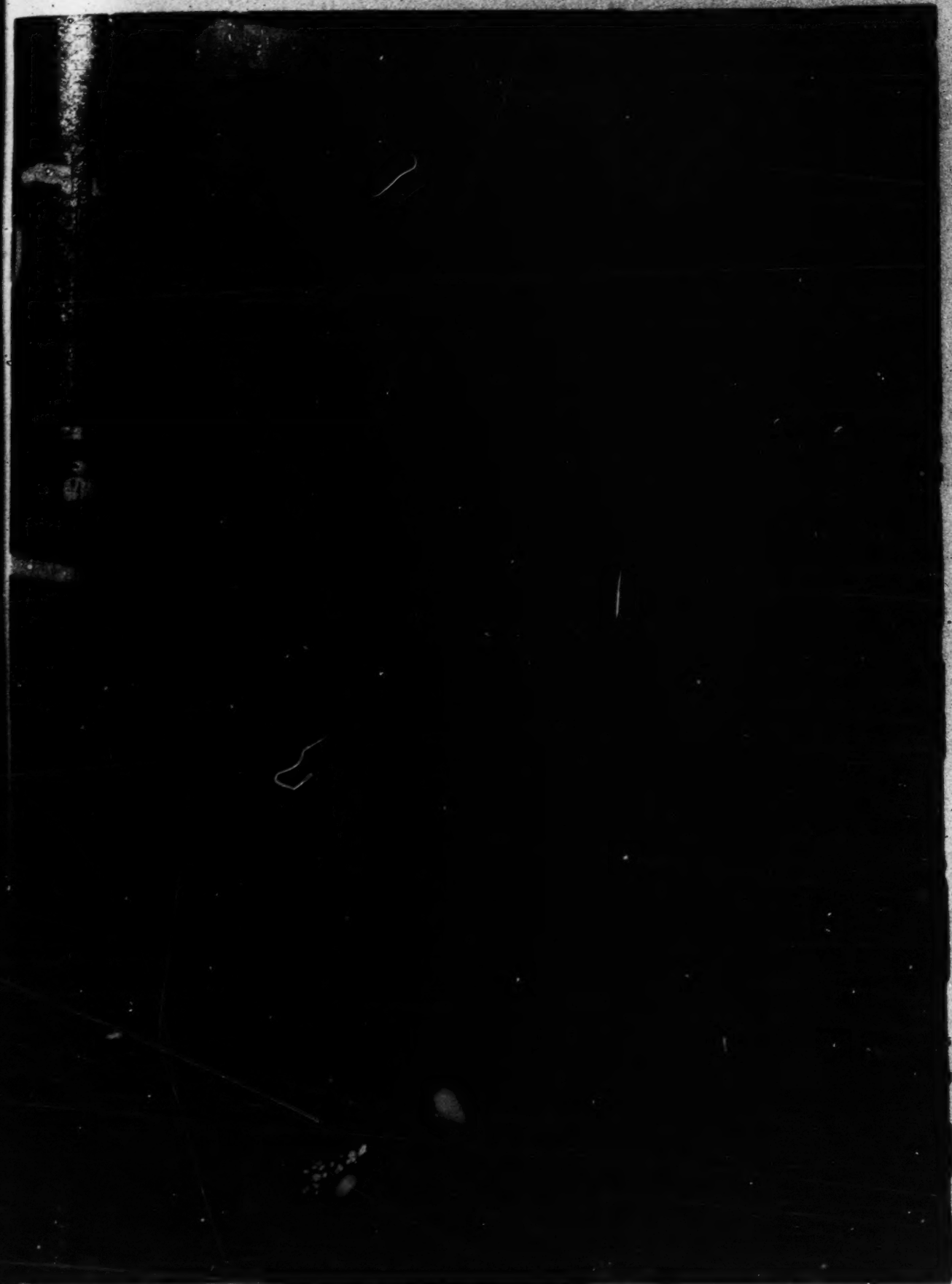
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730

PLAINTIFF S' EXHIBIT No. 35

Photograph of Defendant's amplifiers



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**PAGE**



Plaintiffs' Exhibit No. 32.

(Letterhead of)

GENERAL TALKING PICTURES CORPORATION  
Executive Offices  
218 West 42nd Street  
New York City

318 East 48th St.  
November 17, 1928

American Transformer Co.,  
Newark, N. J.

2192

Gentlemen:

*Attention Mr. Crumm.*

I am informed that you are now manufacturing an amplifier panel for use in connection with phonograph and the like in theatres.

Kindly furnish the writer with a complete detailed information regarding the prices in lots of 10 and more and guaranteed dates of delivery.

2193

I assume that this apparatus is licensed under RCA patents.

Awaiting your immediate reply.

Yours very truly,

GENERAL TALKING PICTURES CORP.  
LEE DE FOREST

2194

## Plaintiffs' Exhibit No. 33.

November 23, 1928.

General Talking Pictures Corporation  
218 West 42nd Street  
New York City.

Attention: Mr. Lee de Forest.

Gentlemen:

2195 We have your letter of the 17th in regard to amplifiers to be used with phonograph and the like in theatres.

The license which we have with the Radio Corporation of America is that the amplifier is to be used for broadcasting reception and for experimental and amateurs use only and not for commercial use. That is the type of license notice which is placed upon the amplifier and is the only way which we can sell them.

2196 We are enclosing a bulletin on the last page of which is a general description of the type of amplifier to which we are referring. This amplifier can be made up in quantities at a price which is dependent on a large measure on the details of the input and output circuit required. These two points are critical and have to be designed to fit the input circuit and the load that is to be placed on the amplifier so that if you wish to obtain any of these amplifiers, it is necessary to have a good deal of information regarding the output circuit.

In general, the amplifier is furnished to operate from a radio receiver located at some distance from the amplifier and the connection be-



tween the two is made by means of a 200 ohm line and proper stepdown and stepup transformers. The control of volume is either ahead of the detector tube or in the 200 ohm line. The amplifier consists of three stages of audio, completely operated on A C using 27 tubes in the first stage, push-pull 26 tubes in the second stage and push-pull 260 tubes in the third stage, either two or four as desired. The output circuit is preferably designed to operate through a 200 ohm line so that the energy can be distributed to the speakers at some distance from the amplifier using stepdown transformers at the end of the line to match the impedance of the various speakers.

2198

The list price on such an amplifier is approximately \$1200.00 and there is a large discount for quantity orders. In general, the discount is 50%, but as mentioned before, the direct price is dependent on the output circuit and it does not pay to quote any definite price until we have more definite information.

Delivery can be made in about five weeks from receipt of order and complete information.

2199

I will be very glad to go into further detail with you regarding this matter and if necessary will have our representative call on you.

Yours very truly,

AMERICAN TRANSFORMER COMPANY

GCC:VS

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33 Edes

# AmerTran Radio Products

Standards of Excellence for Radio Reproduction

## AmerTran Audio Transformers

### AmerTran De Lens

The standard of excellence for audio reproduction. The approach to ideal reproduction with AmerTran De Lens audio transformers is so close that any further improvement which might be revealed by scientific laboratory instruments could not be detected by the ear with the best existing commercial recorded dubbing. Made in two types, the first stage, turn ratio 3:1; the second stage, turn ratio 4:1; completely shielded and sealed in with a waterproof compound, high permeability alloy and in the case. Approximate shipping weight, 144 lbs. List price, each, \$10.00.

### Input Type 151

Is an interstage audio transformer similar to the 2nd Stage AmerTran De Lens except that its secondary has a carefully balanced center tap and the maximum turn ratio is 5 (full secondary). Ratio of primary to each half of secondary 2½. It can be used providing any type of power tube. The frequency characteristic is slightly flatter than that of the second stage AmerTran De Lens when connected for 2½ to 1 turn ratio. Approximate shipping weight 2 lbs. List price, each, \$15.00.

### Output Type 153 (Impedance Ratio 4:1)

Is designed to work out of UX 250 tubes, or tubes of similar plate impedance into a speaker having approximately the impedance of W. E. type 640 AW cone, Brown-Ing-Dolan, Farrand and similar speakers. The primary winding has a carefully balanced center tap. Approximate shipping weight 2 lbs. List price, each, \$15.00.

### Output Type 271 (Impedance Ratio 2:1)

Is designed to work out of UX 171, or tubes of similar plate impedance, into a speaker having approximately the impedance of a WE type 640 AW Cone. The primary has a carefully balanced center tap. Approximate shipping weight 2 lbs. List price, each, \$15.00.

### Output Type 280 (Impedance Ratio 2000:1)

The primary of this output transformer is identical with that in type 152, and designed to work out of UX 210 tubes, or tubes of similar impedance. The secondary is designed for connecting directly to the moving coil of dynamic type speakers, such as the Jensen, Maguire, etc. Approximate shipping weight 2 lbs. List price, each, \$15.00.

### Output Type 343 (Impedance Ratio 530:1)

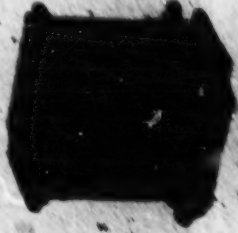
Designed to work out of 171 tubes into the moving coil of dynamic type loud speakers. The center tapped primary on this transformer is similar to the primary of type 271. Approximate shipping weight 2 lbs. List price, each, \$15.00.

### Output Type 678 (Impedance ratio 480-160-120-33.7)

This has a center tapped primary suitable for working out of two 250 tubes: 78 m. current capacity each half of primary. Secondary contains two separate 15 ohm coils and one 45 ohm coil, providing suitable combinations for 1, 2, 3, 4, 5, 6, 7, 8 or 9 dynamic speakers, or all in series for 200 ohm line. Shielded magnetically within a cast aluminum case. Approximate shipping weight, 5 lbs. List price, \$25.00.

### Intermediate Type 710 (Turn ratio 1¼)

This transformer has suitably primary and secondary coil sections with a carefully balanced center tap in both primary and secondary. It may be used between two pairs of push-pull tubes. It is carefully shielded magnetically within a cast aluminum case. Approximate shipping weight, 4 lbs. List price, \$20.00.



AmerTran De Lens



Input or Output Transformer



Type 710 of Type 678

Edes



## AmerTran Audio Transformers—continued

### Equalizer Type 200

is designed to adjust the impedance of an electric phonograph pickup to the primary impedance of the last stage AmerTran De Luxe. Three primary taps are provided to compensate for three variations in the impedance of the last available electrical pickup. Approximate shipping weight 2 lbs. List price, each, \$20.00.



Equalizer Type 200

## AmerTran Power Transformers

### Type PF 52-A

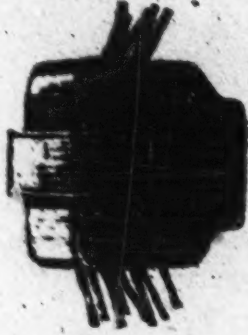
For D. C. output of approximately 400 volts, 100 ma. half wave with UX 281 or 281A tubes, 100 ma. full wave, with UX 281. Two center tapped filament windings, 7½ volts each.

This new power transformer replaces both the PF 64 and the famous PF 52. It is similar to PF 52 except that the plate winding has been extended to 600 volts A. C. and provided with a center tap (300 volts each side of tap). This winding will safely carry from 200 to 120 ma. continuously, either when operating half wave with UX 281 or full wave with UX 281A. Two filament windings, 7½ volts 2½ amperes each, have center taps. When used with lower voltage tubes suitable rheostats must be provided to lower the filament voltages. Primary 50 or 60 cycles tapped for 100, 110, 115, 120 volts. Not provided with switch, cord or plug. Approximate shipping weight 10 lbs. List price, each, \$20.00.

### Type PF-281

For D. C. output of 425 to 650 volts, 110 ma. with UX 281 half wave rectifying tube—Power tube UX 281. Heater windings for A. C. tubes.

This is a power transformer for half wave rectification with a UX 281 rectifying tube, to be used on 50 or 60 cycle, 110 volt circuits. It is rated 150 V. A. continuous load and has a plate winding for 750 volts A. C. maximum, 110 milliamperes, with a tap at 350 volts. There are four filament windings, one for 7½ volts, 2½ amperes center tapped for the UX 281 rectifying tube; one for 7½ volts, 2½ amperes center tapped for use with one or two UX 216 power tubes; one for 1½ volts, 10 amperes without center tap for the filaments of UX 226 A. C. tubes; one for 2½ volts, center tapped for the filaments of UX 227 A. C. tubes. There is a copper ground shield over the primary, and primary taps are brought out for 100, 110, 115 and 120 volts. This transformer virtually becomes an A-B-C eliminator when used with A. C. tubes and the proper filter circuit for D. C. voltages of from 425 to 650 volts. Plate current 110 milliamperes. Approximate shipping weight, 25 lbs. List price, \$25.00.



AmerTran Power Transformer

### Type PF-250

For D. C. output of 400 to 450 volts, 200 ma., with two UX 281 rectifying tubes, full wave—Power tubes UX 281 single or push pull.

This power transformer is for full wave rectification with two UX 281 rectifying tubes, having a 1200 volt A. C. plate winding with a center tap (600 volts each side of tap). Current capacity of plate winding 100-200 ma. Each of the two 7½ volt center tapped filament windings are sufficient for two UX 281 or two UX 250 tubes with their filaments in parallel. Primary 50 or 60 cycles tapped for 100, 110, 115 and 120 volts. Approximate shipping weight, 27 lbs. List price, each, \$30.00.

### Type H-67 Heater Transformer for A. C. Tubes

Filament supply for UX-226, UY 227, Kellogg A. C. tubes and UX 171.

This transformer has a rating of 40 V. A., for use on 50 or 60 cycle, 110 volt circuits. It has a copper ground shield over the primary, and there are three separate heater windings, each with a center tap; one for 1½ volts with sufficient capacity for the filaments of 6 UX 226 A. C. tubes; one for 2½ volts sufficient for 4 UY 227 A. C. tubes or 3 Kellogg A. C. tubes; and one 5-volt winding for the filaments of one or two UX 171 tubes. Primary tap voltages, 100, 110, 115 and 120. The H-67, when used with the A. C. tubes specified, is virtually an "A" eliminator. Approximate shipping weight, 9 lbs. List price, \$12.00.



Heater Transformer Type H-67



## AmerTran Choke Coils

### AmerChoke Type 418

2 amperes,  $\frac{1}{4}$  Henry, D. C. Resistance, 0.5 ohms.

This is a filter choke having a current capacity of 2 amperes and an inductance of approximately  $\frac{1}{4}$  Henry when loaded. D. C. Resistance is approximately 0.5 ohms. It is intended primarily for use in "A" eliminator circuits and for removing the commutator ripple from D. C. circuits. Approximate shipping weight, 5 lbs. List price, \$6.00.

### AmerChoke Type 854

60ma., 50 Henries, D. C. Resistance, 600 ohms.

This is a filter choke having a current capacity of 60 milliamperes and an inductance of approximately 50 Henries when loaded, depending on the core gap setting. D. C. Resistance is approximately 600 ohms. It is intended primarily for use in filter circuits of "B" eliminators and as an output choke for the loud speaker. The two gaps in the magnetic circuit are adjustable for obtaining maximum inductance for various loads. Approximate shipping weight, 5 lbs. List price, \$6.00.

### AmerChoke Type 709

120 ma., 15 to 20 Henries, D. C. Resistance, 210 ohms.

This is a filter choke having a current capacity of 120 milliamperes and an inductance of from 15 to 20 Henries when loaded. D. C. Resistance is approximately 210 ohms. It is recommended for use in any filter circuit requiring more than 60 milliamperes load. In construction it is similar to the Type 854. Approximate shipping weight,  $\frac{5}{16}$  lb. List price, \$6.00.

### AmerChoke Type 857 (Filter)

250 ma., 20 Henries, D. C. Resistance 110 ohms.

A heavy duty choke of high inductance for use in filter circuits passing up to 300 ma. D. C. It is recommended for circuits in which the D. C. current exceeds the limits of the type 709 up to 300 ma. Approximate shipping weight, 14 lbs. List price, \$12.00.

### AmerChoke Type 641 (Output Only)

400  $1\frac{1}{2}$ % full winding, each half 60 ma. 275 ohms D. C.

This is an audio output impedance with center tap designed to take the plate current of two 250 tubes or smaller power tubes. It contains four sandwiched coil sections arranged and connected for absolute electrical symmetry on both sides of the center tap. Current capacity 60 milliamperes each side of center tap. Mounted in metal cans sealed with insulating compound. Five terminal posts on bakelite cover. Approximate shipping weight 5 lbs. List price, \$10.00.

### AmerChoke Type 101 (Output or Filter)

60 ma., 40 Henries, D. C. Resistance 275 ohms.

This output choke coil is intended for the plate circuit of a single 250 or similar power tube and has a flat audio frequency characteristic from 40 to 9,000 cycles. It may also be used as a filter choke. Approximate shipping weight, 6 lbs. List price, \$10.00.

## AmerTran Resistors (Voltage Dividers)

### Type 400

Plate voltage tapped potentiometer.

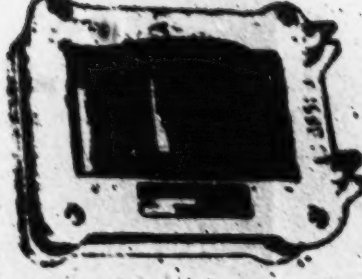
This is a wire-wound double-tube resistor for use across the output of 400 volt filter circuits and is provided with taps conveniently arranged for obtaining practically all intermediate plate voltages below the maximum. Approximate shipping weight, 1 lb. List price, \$7.50.

### Type 500 AmerTran Dual Adjustat

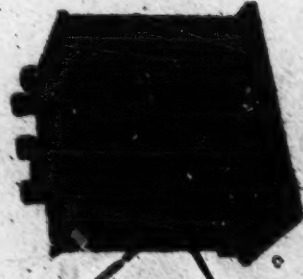
This voltage divider has a total resistance of approximately 41,000 ohms—with fixed terminals at 0, 6,000, 31,000, and 41,000 ohms. In addition there are two rotary switch blades which provide 2 variable plate voltages in 15 steps from 6,000 to 31,000 ohms each. Approximate shipping weight,  $1\frac{1}{4}$  lbs. List price, \$8.50.



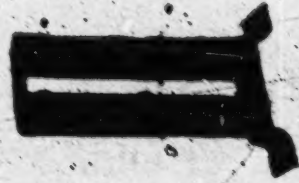
AmerChoke Type 418, 709, or 854



AmerChoke Type 857



AmerChoke Type 641



AmerTran Resistor Type 400



AmerTran Dual Adjustat Type 500



## AmerTran Line Adjusting Transformers

**Type 976 Auto Transformer (Converts 220 Volt A.C. to 110 V.A.C.)**

200 V.A. capacity, 50 or 60 cycles, 110-220 volts.

In many localities the home lighting circuits are 220 to 230 volts. Type 976 steps this voltage down to 110-115 volts with ample capacity for the largest 110-115 volt A.C. operated receivers and eliminators. Approximate shipping weight 10 lbs. List price, each, \$20.00.

## Licensed AmerTran Power Devices\*

**Push-Pull Power Stage Type P— (Power Stage Only)**

*Push-Pull Input and Output Transformers, power tube sockets with grid resistors wired and mounted on a metal base.*

The Type P— AmerTran power stage consists of a Type 151 Input and either a Type 152, 271, 280, or 352 Output transformer (depending upon the combination of power tubes and speaker desired) mounted on a metal base and wired to two power tube sockets with necessary 50,000 ohm resistances in the C— lead. Licensed under patents owned or controlled by the Radio Corporation of America and sold with or without RCA or Cunningham tubes. Approximate shipping weight, 10 lbs. List price, each of Rocky Mountains, without tubes, \$36.00.

**AmerTran Push-Pull Amplifier Type 2AP**

A complete two stage audio amplifier with first stage AmerTran De Luxe and second stage AmerTran Push-Pull for two power tubes. Designed to use one UY 227 A.C. tube in the first stage and two 171 or two 210 power tubes in the push-pull stage. Licensed under patents owned or controlled by the Radio Corporation of America and sold with or without RCA or Cunningham tubes. Approximate shipping weight, 20 lbs. List price, each of Rocky Mountains, less tubes, \$60.00.

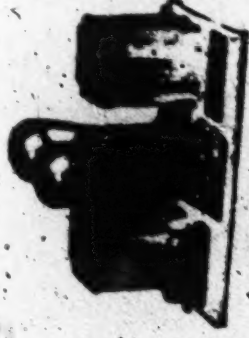
**AmerTran ABC Hi-Power Box Type 21-D**

300 volts D.C. plate and lower tap voltages, plate currents up to 100 ma.; A.C. filament current for a 281 rectifier, two 210 power tubes and several 226 and 227 A.C. tubes. Adjustable negative bias voltages for all tubes. Licensed under patents owned or controlled by the Radio Corporation of America and sold with or without rectifying tube. Approximate shipping weight, 50 lbs. List price, each of Rocky Mountains, less tubes, \$95.00.

**AmerTran Concert Hall Type Amplifier—Type 25A**

This is a powerful reproducer of the switchboard type intended for use with a variety of loud speakers in auditoriums, theatres, churches and open air amusement resorts. It can be adapted for working out of a detector tube, 200 ohm line or any circuit the impedance of which is known, and the output can be adjusted for from one to nine dynamic speakers, a 200 ohm line or for high impedance speakers, all at full volume. It contains a three stage double push-pull audio amplifier and power supply mounted on the rear of a vertical metal panel 5 ft. high and 21 in. wide, supported at the sides with 3 in. channels. It is operated completely from the 110 volt 60 cycle lighting circuit and in addition to furnishing power for the amplifier, provides additional B.C. and heater voltages for the usual radio tuner. The UX-250 or CX-350 power tubes in the last push-pull stage provide an undistorted power output of approximately 12 watts at full load and the frequency characteristic is substantially flat over the entire audio range. This apparatus is licensed under patents owned or controlled by the Radio Corporation of America. Prices on application stating input and output requirements.

\*Licensed Devices Are Not Subject to Same Discount As Other Parts Listed in This Bulletin.



Type 976—  
Push Pull Power Stage



Type 2AP  
2 Stage Push Pull  
Power Amplifier



Type 21-D  
ABC Hi-Power Box

American Transformer Company  
178 Emmet Street  
Newark, N. J.

PRINTED IN U. S. A.

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**PAGE**



PLAINTIFF'S EXHIBIT No. 34

731

Photograph of the License Notice Plates  
attached to the defendant's amplifiers



60128



Agreement made the 20th day of February 1928, between GENERAL TALKING PICTURE CORPORATION of 218 West 42nd Street, Manhattan, New York City (hereinafter called the COMPANY) and STRAND THEATRE COMPANY of ALLENTOWN, PA. (hereinafter called the EXHIBITOR).

In consideration of the terms, conditions and covenants herein contained the parties have mutually agreed as follows:

1.-The COMPANY hereby grants to the EXHIBITOR a personal, non-exclusive, indivisible license to use in the STRAND Theatre building a valid show on screen in the City of ALLENTOWN

State of PENNSYLVANIA (hereinafter called the THEATRE), the equipment described in paragraph 2 hereof (hereinafter called the EQUIPMENT) for the reproduction of sound in connection with the exhibition of motion pictures, under the patent rights now or during the term hereof controlled by the COMPANY or with respect to which it shall have the right to grant such license.

2.-The EQUIPMENT is for installation in one booth with two (2) Nitelyx Projectors equipped with 1 1/2 H. P. motors to be furnished by the EXHIBITOR and consists of:

- (A) Two (2) Phonofilm sound reproduction system.
- (B) Two (2) preliminary amplifiers and tube control.
- (C) One (1) "B" amplifier and power supply unit.
- (D) One (1) set of loud speakers.
- (E) Tube necessary to complete installation.

3.-The COMPANY shall install the EQUIPMENT in the THEATRE and will use its best efforts to complete the installation on or about the 20th day of MARCH 1928.

4.-The EXHIBITOR is to own, rent and occupy

- (A) Shall make any changes and alterations when and as the COMPANY may direct for the proper installation and operation of the EQUIPMENT and for such purposes shall furnish all plans the COMPANY may require, do all wiring and provide all cassettes, cables, drops, screens and other materials, and
- (B) Shall during the term hereof comply with all statutes, ordinances and regulations of any State, Municipal or local authority and of any Federal or State Government, relating to the subject matter hereof.

5.-The EXHIBITOR shall make the following covenants to the COMPANY:

A.-License Fee. ONE THOUSAND TWO HUNDRED AND FIFTY

dollars (\$1,250.00) as or before the expiration of this agreement, receipt whereof is hereby acknowledged. The EXHIBITOR shall also pay to the COMPANY a sum of \$100.00 per week for the use of the EQUIPMENT in the THEATRE, payable in advance on the 1st day of each month. The EXHIBITOR shall also pay to the COMPANY a sum of \$100.00 per week for the use of the EQUIPMENT in the THEATRE, payable in advance on the 1st day of each month. The EXHIBITOR shall also pay to the COMPANY a sum of \$100.00 per week for the use of the EQUIPMENT in the THEATRE, payable in advance on the 1st day of each month.

B.-Insurance. The EXHIBITOR shall insure the EQUIPMENT and the THEATRE building against fire, theft and other risks, and shall maintain such insurance for the term hereof.

C.-Maintenance. The EXHIBITOR shall maintain the EQUIPMENT in good working order and shall repair and replace all parts thereof which may become worn or damaged during the term hereof.

D.-Removal. The EXHIBITOR shall remove the EQUIPMENT from the THEATRE at the expiration of the term hereof, and shall leave the THEATRE in the same condition as it was when the EQUIPMENT was installed.

E.-Assignment. The EXHIBITOR shall not assign, transfer or otherwise dispose of the license granted to it by the COMPANY without the written consent of the COMPANY.

F.-Entire Agreement. This agreement shall constitute the entire agreement between the parties and shall supersede all other agreements, oral or written, between the parties.

G.-Governing Law. This agreement shall be governed by the laws of the State of Pennsylvania.

WITNESSES

COMPANY

EXHIBITOR

WITNESSES

COMPANY

EXHIBITOR

WITNESSES

COMPANY

EXHIBITOR

WITNESSES

COMPANY

6.-The EXHIBITOR shall keep, maintain and operate the EQUIPMENT in good working order and shall be responsible for any damage to the EQUIPMENT or to the THEATRE building caused by the EXHIBITOR or its employees, agents or invitees.

7.-The EXHIBITOR shall keep all parts of the EQUIPMENT in good working order and shall be responsible for any damage to the EQUIPMENT or to the THEATRE building caused by the EXHIBITOR or its employees, agents or invitees.

8.-The EXHIBITOR shall not allow any person to use the EQUIPMENT for any purpose other than the exhibition of motion pictures, and shall be responsible for any damage to the EQUIPMENT or to the THEATRE building caused by such use.

9.-The title to and ownership of the EQUIPMENT and of parts from time to time delivered to the EXHIBITOR, and of all drawings, plans and instructions shall be and remain in the COMPANY, to be returned to it by the EXHIBITOR at the expiration or sooner termination of this license.

10.-The EXHIBITOR shall permit the COMPANY's agents to have access to the THEATRE at all reasonable hours for the purpose of installing, examining and inspecting the EQUIPMENT, and the COMPANY will at the EXHIBITOR'S sole cost and expense make such repairs, removals or alterations as the COMPANY may from time to time deem necessary.

11.-This license shall be for a period of ten (10) years from the date hereof but may be sooner terminated by the COMPANY upon the happening of any of the following events:

- (A) The bankruptcy, winding-up or insolvency of the EXHIBITOR, the assignment of its assets for the benefit of creditors, or the appointment of a receiver of all or any portion of its property;
- (B) The failure or refusal to pay any sum or sums of money now or hereafter due to be paid hereunder by the EXHIBITOR, in which event this license shall be of no effect; or upon the breach or non-performance by the EXHIBITOR of any of the other terms, conditions and covenants herein contained, continuing for more than three (3) days after notice thereof in writing to the EXHIBITOR from the COMPANY;
- (C) The removal of the EQUIPMENT or any part thereof without the written consent of the COMPANY from the place of installation.

The COMPANY shall have the right to retain any sums received by it from the EXHIBITOR pursuant to the terms of this agreement notwithstanding any termination hereunder and without prejudice to its right to recover any additional sums then or thereafter due to it from the EXHIBITOR.

12.-The COMPANY shall not be liable for

- (A) Any breakdown, defect or change of condition in the THEATRE or EQUIPMENT, any interruption of service, any loss or damage to any person or property in or about the THEATRE or elsewhere nor for any damages direct, special or consequential, for any reason whatsoever. The EXHIBITOR agrees to indemnify the COMPANY and save it harmless from any liability or injury in whole or in part resulting from negligence or otherwise or arising out of the installation or use of the EQUIPMENT;
- (B) Any loss, damage or delay caused by strikes, riots, fire, insurrection, war, elements, embargoes, failure of carriers, inability to obtain transportation facilities, acts of God, or of the public enemy, or any other cause beyond the COMPANY'S control, whether or not similar to the foregoing.

13.-The EXHIBITOR shall be liable for the use of the EQUIPMENT in the THEATRE but should the EXHIBITOR cease to operate the THEATRE, the COMPANY, will, at the request and expense of the EXHIBITOR, remove the EQUIPMENT to and install it in such other theatre as the COMPANY may then approve in writing, upon the execution by the new proprietor of a new agreement for the EQUIPMENT for the unexpired term hereof on the same terms and conditions as herein contained, to which the EXHIBITOR shall be a party as guarantor.

14.-The COMPANY, subject to the provisions hereof, will at its own expense defend all actions, which may be brought against the EXHIBITOR during the term hereof for infringement of patents by reason of the EXHIBITOR'S use of the EQUIPMENT in the theatre and for the purposes contemplated in this agreement and will indemnify and save harmless the EXHIBITOR to the extent and for the purposes contemplated in this agreement and will indemnify and save harmless the EXHIBITOR to the extent and for the purposes contemplated in this agreement and will indemnify and save harmless the EXHIBITOR to the extent and for the purposes contemplated in this agreement.

15.-Upon the expiration or sooner termination of this license for any reason whatsoever, the EXHIBITOR at its own cost and expense, shall remove and deliver up possession of the EQUIPMENT to the COMPANY at its factory in good order and condition, reasonable wear and tear excepted, and the COMPANY may remove the EQUIPMENT and for such purposes the COMPANY may, without notice, enter the premises where the EQUIPMENT may be and without any legal proceedings remove and remove the same, and the EXHIBITOR agrees fully to co-operate therein. The EXHIBITOR agrees



12-Nothing herein contained shall be construed as conferring upon the EXHIBITION an exclusive license to operate the EXHIBITION in any place or in generating or producing the EXHIBITION from installing and granting license for the use of the EXHIBITION in competing thereto.

22.—This agreement shall remain in the hands of the SURVEYOR, and copies of the COMPANY but neither the agreement nor the INSTRUMENT shall be assigned, mortgaged, pledged or otherwise disposed of by the LANDITION without the written consent of the COMPANY.

11. This agreement shall be construed in accordance with the laws of the State of New York.

22.-The EXHIBITOR is hereby permitted to operate its present turntable system known as the BICOPHON with the projection machine on which the DE FOREST PNEUMOFIL attachment is added and to hook on and unhook said turntable, which connection shall be made by and at the expense of the EXHIBITION.

IN WITNESS WHEREOF, the parties hereto have duly executed and sealed these presents the day and year first above written.

IN THE FORMULA OF

**GENERAL BANKING BROCHERS CORPORATION**

STRAND NUMBER ONEAK .....

... 1. *Scaph. ...*

... W. H. Green - Tenn. [L 2]

131

RECEIVED 1962

**THE NEW YORK PUBLIC LIBRARY**

## THE NEW YORK PUBLIC LIBRARY

[REDACTED]

**[REDACTED]**

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED

IN WITNESS WHEREOF, I have hereunto set my hand and seal this 1st day of May 1964, at New York, New York, the date of the execution of this instrument.

**WILLIAM H. HARRIS**

By **GENERAL TALKING PARTNERS CORPORATION**, its corporate trustee  
in and which executed the foregoing instrument, that to know the end of said corporation, that the end thereof is and shall  
be to such persons only, that it was called by order of the Board of Directors of said corporation, who then signed  
the same document in the name.

Leah H. H. H.  
New York County Court's Office  
Commissioner's Office  
May 5, 1930

**PENNSYLVANIA**

STATE OF NEW YORK  
IN SENATE  
JANUARY 10, 1967.  
REPORT  
OF THE  
COMMISSIONERS OF THE DEPARTMENT OF ENVIRONMENTAL CONSERVATION,  
IN RESPONSE TO A RESOLUTION PASSED BY THE SENATE ON MAY 18, 1966,  
AND A RESOLUTION PASSED BY THE ASSEMBLY ON JUNE 15, 1966,  
RELATIVE TO THE PROPOSED CANNON POINT NUCLEAR POWER PLANT,  
CATTARAUGUS COUNTY, NEW YORK.

IN THE 27th YEAR OF JANUARY 22 1891 A. N. STODOLSKY

to me having, who being by me duly sworn, he deposes and says that he recalls the *attention, &c.* ; that he is the **PRESIDENT** of the **THEATRE COMPANY**, the corporation described in and which executed the foregoing instrument; that he knows the seal of said corporation; that the seal affixed to said instrument is such corporate seal; that it was affixed by order of the Board of Directors of said corporation; and that he signed his name thereto for the same.

*Joseph B. Hughes*  
ALDERMAN 4th WARD  
My Commission Expires  
on Monday in Jan. 1932.

STATE OF NEW YORK  
COUNTY OF NEW YORK

1950

to me known and known to me to be the individual described in and who executed the foregoing instrument and to duly acknowledge to me that he executed the same.

141



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**PAGE**



Page 17 of 18

82

12

Counting leads section above  $I_0$  to 1000 m.

This series as if 519 independent of magnitude, or  
say dependent on it. See last on ball with 519  
with 513!

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Transformer of inactive element - just changed with  
the transformer. Space I not changed by this.

Quality comparison of audio &amp; music.

Be kind on everything - and give a little  
piece of your heart to the world.

Wash. - Translated & revised a little - still  
ready to be a good many more

1. Chickadee very small bird in the nest  
 2. very small bird in the nest

thought out loud - "Oh - they  
thought out loud - a little more, perhaps."

1502 - 2nd floor, as reported from 11/1/77 - 1/1/78

Then inside 2.2 ~~days~~. Aired 7<sup>th</sup> April  
6<sup>th</sup> with green quality - then blue

1978 Note of audience regarding different up to.

1st. 6 1/2 ft. ingers in about 20" and in  
over 70". These into one with 07.08.

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24	tail	gain	tail	gain	tail	gain	450	+200
25	tail	gain	tail	gain	tail	gain	450	(high 200-400)
26	tail	gain	tail	gain	tail	gain	490	+200
27	tail	gain	tail	gain	tail	gain	340	+70
28	tail	gain	tail	gain	tail	gain	240	+70
29	tail	gain	tail	gain	tail	gain	640	+150
30	tail	gain	tail	gain	tail	gain	620	+50

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PLAINTIFF'S EXHIBIT No. 30

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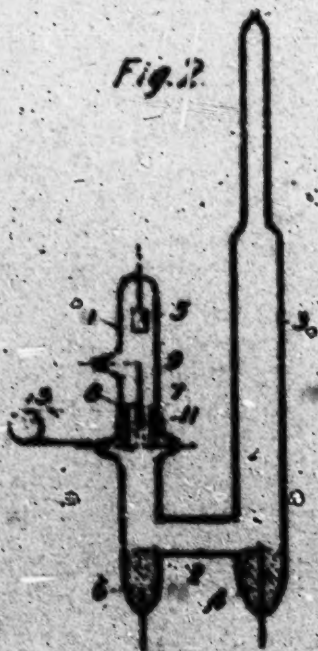
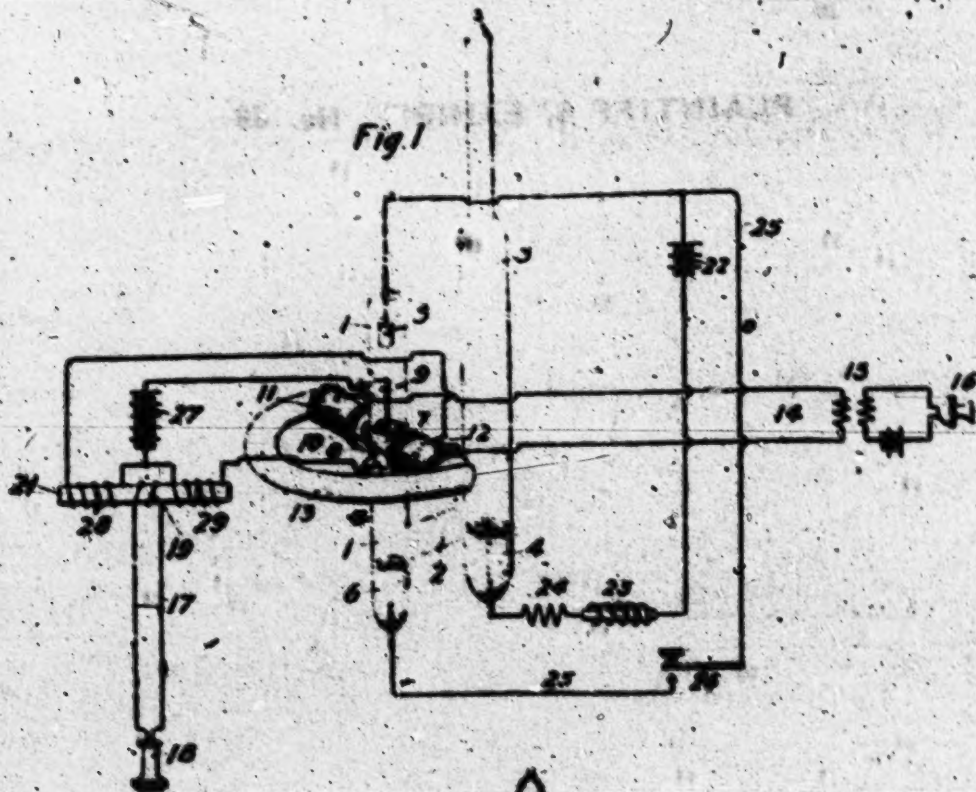


738

H. DE F. ARNOLD.  
METHOD OF REPRODUCING ELECTRICAL VARIATIONS.  
APPLICATION FILED JULY 5, 1912

1,118,172.

Patented Nov. 24, 1914



Witnesses  
W. F. Hoffman.

Inventor  
Harold D. E. Arnold  
by John B. Roberts  
Att'y



# UNITED STATES PATENT OFFICE.

HAROLD DE FOREST ARNOLD, OF NEW BRUNSWICK, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS

METHOD OF REPRODUCING ELECTRICAL VARIATIONS

1,118,172.

Specimen of Printed Form.

Patented Nov. 24, 1914.

Application filed July 15, 1902. Serial No. 76866.

To all whom it may concern:

Be it known that I, HAROLD DE FOREST ARNOLD, a citizen of the United States, residing at Belvidere, in the county of Kane and State of New Jersey, have invented a certain new and useful improvement in Methods of Reproducing Electrical Variations, of which the following is a full, clear, concise, and exact description.

This invention relates to the art of reproducing electric variations; its objects are to secure amplified reproduction of variations of current energy, reproduction without distortion, convenience in minute currents, efficiency, reliability, and automatic operation.

Among other uses the invention is applicable to telephony, for the purpose of obtaining in an outgoing circuit an amplification of voice currents originating in an incoming circuit.

It is also applicable to telegraphy, and signaling systems generally where amplification is desirable in receiving, recording or reproducing impulses of electrical energy.

In carrying out the invention use is made of the principle of deflection by an electromagnet or other suitable means of an ionized stream which may be produced in any of a number of ways. The mercury arc has been found to be a suitable agent for the purpose. The current variations to be reproduced or reinforced may be impressed on the coils of an electromagnet so placed that the variations of magnetism induced therein produce corresponding deflections of the ionized stream. The invention does not depend upon any effect in current flow which such deflection may have on the stream of the ionized stream but involves a novel method, which will now be explained, of detecting and utilizing the variations produced by the deflecting agent.

The detecting means of this invention involves the use of an auxiliary circuit which is non-existing in character and independent of the circuit for establishing the ionized stream, except that it intercepts a portion of the vapor of the stream. This auxiliary circuit is maintained by means of an auxiliary cathode or pair of such cathodes ionized in the stream and connected to a source of electro-motive force which may be separate and distinct from

the source producing the stream itself, the circuit being completed through an anode which may likewise be ionized in the stream. There is thus established in the vicinity of the auxiliary cathode or cathodes an electrical field, which causes in the auxiliary circuit a flow of current the intensity of which is directly dependent upon the distribution of ionization in the auxiliary cathode field.

The invention will be more fully understood by reference to the accompanying drawings wherein: Figure 1 shows a system of circuits and apparatus by which the method hereinafter claimed may be carried out and Fig. 2 shows in elevation and cross section the apparatus of Fig. 1 separated from the circuits.

Referring to the drawings, the means for producing the ionized stream, which in this instance I have shown as a mercury arc apparatus comprising a main chamber 1 with a horizontal branch 2 and a condensing chamber 3 together with a mercury cathode 4, an anode 5 of carbon or other suitable material, and a starting mercury anode 6. Supported within the main chamber 1 are a pair of auxiliary cathodes 7, 8 which are shown semi-cylindrical in form and slidably separated from each other and from the walls of the chamber. Extending downwardly between the auxiliary cathodes is an auxiliary anode 9. The auxiliary cathodes and the auxiliary anode may be of platinum, or other suitable conducting material. Leading-in conductors preferably of platinum wire are provided for the several electrodes of the device.

As the means for deflecting the ionized stream, I have shown an electromagnet 10, the means of support of which is not shown. Each magnet comprises a pair of coils 11, 12, surrounding inwardly extending pole pieces the outer ends of which are joined by a semi-circular yoke 13. The pole pieces present their faces to opposite sides of the main chamber 1 in the region of auxiliary cathodes 7, 8 so that the lines of force between the pole pieces are in a direction transverse to the direction of flow of the ionized stream in the chamber 1 and operate to deflect the stream in the direction of one auxiliary cathode or the other, according to the direction of the current in the magnet coils.

The system shown in Fig. 1 comprises five circuits—(1) an incoming circuit 14 including the coils 11, 12 of the electromagnet 10 and the secondary of an induction coil 13, the primary of which is in (2) a local circuit containing a source of current and a transmitting device such as the telephone transmitter 16; (3) an outgoing circuit 17 including a receiving device such as the telephone receiver 18 and the secondary winding 19 of a transformer 21; (4) an energizing circuit for the mercury arc comprising a battery 22, impedance coil 23 and resistance coil 24, this circuit being connected, one terminal to the anode 3 and the other terminal to the cathode 4, and having a starting branch 25 connected, one terminal to the battery 22 and the other to the starting anode 6 and including a starting key 26; and finally (5) the auxiliary detecting circuit including a battery 27, one terminal of which is connected to the auxiliary anode 9 and the other branching through balanced primary windings 28 and 29 of the transformer 21 to the auxiliary cathodes 7 and 8 respectively.

The impedance coil 23 and resistance coil 24 provide a balance for the mercury arc circuits to maintain a steady flow of current therein which, when once established as by tipping the key 26, closing the circuit at the starting key 26 over the path 22, 23, 24, 4, 3, 6, 25, 26, 22 and then releasing the key 26 is maintained automatically over the path 22, 23, 24, 4, 3, 1, 6, 25 which includes the ionized arc stream in the main chamber 1. This stream passes by and in contact with the auxiliary cathodes 7 and 8, filling the region between them, and rendering the auxiliary circuit conductive so that current flows from the battery 27 dividing through the primary windings 28 and 29 of the transformer 21 to the auxiliary cathodes 7 and 8, and through the ionized vapor in between and by way of the auxiliary anode 9 back to the battery 27. It is noteworthy of this auxiliary circuit that it is un-arc-ing in character and that the potential difference existing between the auxiliary electrodes is independent of, and in fact may be very much greater than, that existing between the electrodes of the arc stream. At the same time the current flow in the auxiliary circuit may be very much less than that in the arc circuit. For example, in one particular embodiment of the apparatus the potential difference existing between the auxiliary anode 9 and the auxiliary cathodes 7 and 8 was 100 volts whereas that between the anode 3 and cathode 4 of the arc was 20 volts. The current flow in this instance was .04 amperes in the auxiliary circuit and one ampere in the arc circuit. The primary coils 28, 29 of the transformer 21 are wound differently in the auxiliary circuit, that is to

say, in such a direction with respect to each other that the core thereof under normal conditions of the circuit is not magnetized. The normal current flows equally or approximately so in the two branches, this being due to the symmetrical arrangement of the auxiliary cathodes 7, 8 with respect to the ionized vapor in the space between them. When, however, the electromagnet 10 is energized by current received over the incoming circuit, 14, a magnetic field is produced which deflects the stream toward one electrode or the other. The effect of this is a change in the distribution of ionization in the field or region adjacent the auxiliary cathodes and current will flow with increased strength through one primary winding of the transformer and with decreased strength through the other thereby inducing current in the secondary winding which is transmitted over the outgoing circuit 17 and recorded or made manifest in the receiving instrument 18. In this manner minute variations of current energy such as those transmitted over great distances by a telephone or signalling device and delivered to the instrument by the incoming circuit 14 are reproduced and amplified in the outgoing circuit 17. The extremely small mass of the ionized vapor which is deflected by the electromagnet enables the reproduction of current variations to be accomplished without distortion. By reason of the non-arc-ing character of the detecting circuit the relaying of current variations is accomplished without disturbing or "noisy" currents in the outgoing circuit, this being of especial importance in telephone transmission systems.

I have illustrated and described two auxiliary cathodes and a branched circuit through balanced primary windings 28 and 29, for the reason that I have found that such arrangement produces the best results. My fundamental invention would, however, be embodied in an arrangement in which only one auxiliary cathode and one primary winding are employed. Also the auxiliary anode 9 may be omitted and the battery 27 may be connected with the anode 3, without departing from the spirit of my invention. Moreover, while I prefer to use two magnet coils 11 and 12, one of them may be omitted, and indeed, the arc stream may be caused to be deflected by electro-static instead of electro-magnetic means.

I claim:

1. The method of reproducing electrical variations which consists in establishing an ionized stream, maintaining a circuit including a transverse path within said stream, applying at a point within said path a variable deflecting force to said stream, and producing thereby current variations in the said circuit.



2,329,175

3. The method of reproducing electrical variations which consists in establishing an arc, maintaining an auxiliary non-arcing circuit in a transverse path within said arc, applying at a point within said path a variable deflecting force to said arc, and producing thereby current variations in said auxiliary circuit.

4. The method of reproducing electrical variations which consists in establishing an ionized arc stream, maintaining an auxiliary non-arcing circuit including a transverse path within said stream, applying at a point within said path a variable deflecting force to said stream and producing thereby current variations in the said auxiliary circuit.

5. The method of reproducing electrical variations which consists in establishing an ionized stream, maintaining a balanced non-arcing circuit having two paths through a portion of the ionized vapor of said stream, deflecting said stream to and fro between said paths in accordance with current variations in an incoming circuit and transforming in an outgoing circuit the current variations thereby produced in the balanced circuit.

In witness whereof, I have hereunto set my hand this 12th day of July, A. D. 1911.

HAROLD DE FOREST ARNOLD.

Witness:

MURRAY V. COWLEY,  
FRED DUNLAP.

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Plaintiffs' Exhibit No. 40.

[B2]

SUBSTITUTE  
LICENSE AGREEMENT

DATED JULY 1, 1932

BETWEEN

GENERAL ELECTRIC COMPANY

2228

AND

AMERICAN TELEPHONE AND TELEGRAPH COMPANY

AGREEMENT dated July 1, 1932, between GENERAL ELECTRIC COMPANY, a New York corporation (herein called the General Company), and AMERICAN TELEPHONE AND TELEGRAPH COMPANY, a New York corporation (herein called the Telephone Company).

WHEREAS the parties hereto heretofore entered into an agreement made the first day of July, 1920, generally known as Agreement "B", which was subsequently modified by an agreement dated July 1, 1926, generally known as "Modified Agreement B", and

2229

WHEREAS it is now the mutual desire of the parties to substitute therefor this agreement and the licenses herein granted.

Now, in consideration of the premises and the mutual agreements herein contained, the parties agree each with the other as follows:



2230

*Plaintiffs' Exhibit No. 40.*

---

**ARTICLE I.****TERMINATION OF EXISTING AGREEMENTS AND  
LICENSES.**

The said agreements of July 1, 1920, and July 1, 1926, generally known as Agreement B and Modified Agreement B, respectively, and all licenses therein granted and agreed to be granted are hereby terminated as of the date hereof, and this agreement and the licenses herein granted and agreed to be granted are substituted therefor.

2231

**ARTICLE II.****DEFINITIONS.**

For the purposes of this agreement the following terms are defined as follows:

2232 "Wire telephony" is the art of communicating or reproducing sound waves (created, directly or indirectly, by the voice or by musical instruments) by means of electricity, magnetism or electro-magnetic waves, variations or impulses conveyed or guided by wires, and includes all generating, measuring, switching, signaling and other means or methods incidental to or involved in such communication.

"Wireless telephony" has the same meaning as "wire telephony", except that the waves, variations or impulses are radiated through space.

*"Wire telegraphy"* is the art of communicating messages by code signals (such as the Morse Code, for example) and of picture transmission, by means of electricity, magnetism or electro-magnetic waves, variations or impulses conveyed or guided by wires, and includes all generating, measuring, switching, signaling and other means or methods incidental to or involved in such communication, but does not include such devices as annunciators, elevator signals, engine room telegraphs, etc.

2234

*"Wireless telegraphy"* has the same meaning as *"wire telegraphy,"* except that the waves, variations or impulses are radiated through space.

*"Picture transmission"* is the art of transmitting, or receiving at another point than the point of transmission, by means of electricity, magnetism or electro-magnetic waves, variations or impulses, the aspect or shape of things, including pictures, whether still or moving, drawings, writings, forms and other graphic, printed and written matter of all kinds; and includes television.

2235

*"Programs"* means pictures, news, music, speeches, sermons, advertising and entertainment, educational and similar matter, or any of them or combinations of any of them, for the purpose of exhibition, entertainment or instruction.

*"Power purposes"* means all prime movers and their accessories and all generation, use,



2236

Plaintiffs' Exhibit No. 40.

measurement, control and application of electricity for light, heat, power and traction, but does not include any communication purpose.

2237

"*Public address system*" means a combination including one or more telephone transmitters, an electrical amplifier or amplifiers and one or more loud speaking telephone receivers, either adjacent to said transmitters or at a distance therefrom, operating by one-way wire telephony for the reproduction of sound with increased volume, but does not include apparatus for (1) wireless telephone reception, or (2) reception of programs over electric light, electric heat, electric power or electric traction lines, or (3) the production or reproduction of sound from sound records.

2238

"*Phonographs*" means all apparatus for the reproduction of sound from sound records used in or in connection with such apparatus, to be heard in the immediate vicinity of the apparatus, but does not include apparatus for the transmission to, or reception at, other points of sound reproduced from such records.

"*Electric Phonograph*" means a phonograph in which the sound record used therein gives rise to or controls an electric current or electromotive force in such a way that the variations of the electric current or electromotive force correspond in some way to the recorded sounds, and the electric current or electromotive force directly or indirectly brings about the production of the sound from the phonograph.

"*Transoceanic*" communication means all communications which crosses any ocean, gulf or

sea between two continents, or between a continent and an island more than one hundred miles from its shores (islands within one hundred miles of the shores of a continent being considered parts thereof); or between two islands which are not parts of the same continent, except that communication between ships or aircraft, between ships and aircraft, or between ships or aircraft and shore, and communication between parts of the same continent, is not transoceanic communication. North America, including the Panama Canal Zone and all of Central America north thereof, is to be considered as one continent, and South America and all of Central America south of the Panama Canal Zone as another.

2240

"The United States Government" means not only the Federal Government but also the Governments of the Philippines, Porto Rico and other federal possessions, present or future; but does not include any municipal, county or state government.

2241

"Train dispatching" is telegraphic or telephonic conveyance of train orders or operating information between the office of a train dispatcher or similar official and railway trains or other automotive land vehicles (not including airplanes or airships) or points along the line of way, for directing the movements of such automotive vehicles.

"Railway signalling" is the operation of signals, switches, brakes, stops, crossing gates, etc., controlling or signalling the movements of trains.



2242

*Plaintiffs' Exhibit No. 40.*

or other automotive vehicles, controlled by or in accordance with train or vehicle movements or track conditions, including block signaling, cab signals and train stops. It does not include train dispatching.

"*Apparatus*" includes machines, devices and appliances and the materials entering into the construction thereof.

2243

"*Household devices*" are electric or electrically operated apparatus, not herein otherwise specified, designed primarily for domestic use, but do not include apparatus for communication purposes.

"*Homes*" means all places of residence, permanent or temporary, including, however, as to hotels, hospitals and club houses only the private living rooms thereof.

2244

"*Amateur*" means one, not a professional investigator, who is more than a mere broadcast listener and who evidences his interest in the art of wireless telephony by study, investigation or experiment in the art.

"*Printing telegraph apparatus*" means, and is limited to, mechanisms and devices for use in telegraphy, whether wire or wireless, whereby electrical signals corresponding to the characters of a message

(a) are created in an electric circuit by the operation of a manual device upon which such characters are represented, or by the

opération of an automatic transmitter controlled by a tape or other record having holes or other marks corresponding respectively to the characters of the message impressed thereon by the operation of such manual device, and/or

(b) are utilized to cause said characters to be successively recorded or displayed (directly or through storage means) in typed or other form, or are utilized to select successively devices or elements corresponding to said characters, and/or

(c) are sequentially distributed or delivered by the apparatus referred to in clause (a) to a transmission channel; (such as a wire circuit, carrier-current circuit, or radio apparatus) or from a transmission channel to the apparatus referred to in clause (b);

but this definition does not include the transmission channel or any apparatus, circuits, systems or methods for electrical transmission or reception the functions of which are distinct from those of the apparatus referred to in clauses (a), (b) or (c) hereof, nor any mechanism or devices for enabling automatic comparison of sequential repetition of said signals or records thereof; and this definition does not include any apparatus for "picture transmission" as herein defined.

"Subsidiaries" of either party are corporations a majority of whose stock having power to vote for the election of directors is owned, di-



2248

*Plaintiffs' Exhibit No. 40.*

rectly or indirectly, either by such party, or by such party and one or more of its other subsidiaries, or by one or more of its other subsidiaries. The party hereto so controlling, directly or indirectly, any subsidiary is herein called the "parent company" of such subsidiary.

2249

"Companies of the Bell System" are those companies which, in connection directly or indirectly with the Telephone Company, provide a telephone service throughout the United States, or from the United States to foreign countries. These companies at present comprise the Telephone Company, Western Electric Company, Incorporated, Cuban American Telephone and Telegraph Company, and the so-called Associate Companies and Connecting Companies, and the several subsidiaries of each of said Companies.

Any dispute arising as to the meaning or application of the foregoing definitions shall be settled by arbitration, as hereinafter provided.

2250

**ARTICLE III.****THE PATENTS INCLUDED IN THE AGREEMENT.**

The licenses provided for herein are granted and agreed to be granted under all patents, and rights to or under patents, of the United States now or hereafter during the term of this agreement owned or controlled by the parties hereto, and under all such patents hereafter issued upon inventions now or hereafter during said term so owned or controlled, and to the extent to which the parties have or may have the right to grant licenses, in so far as the inventions covered by

such patents are or shall be applicable to the respective fields for which said licenses are expressed as granted or to be granted, excepting (1) as otherwise specified in connection with the several grants hereinafter contained, and (2) such patents and inventions as may hereafter be excluded from the operation of this agreement in the following manner:

Each party agrees to furnish to the other, upon request, a list of all United States patents under which said other party is entitled to receive license hereunder. Such lists shall separately identify those patents, and shall also include those applications as to which rights, if granted hereunder, would be restricted in scope or would involve continuing obligations not implied by law. Copies of all contracts creating such restrictions or obligations shall, upon request, be furnished by each party to the other. Thereupon, and within six months after the receipt of the lists to be furnished as aforesaid, each party may in writing advise the other as to the patents and applications described in such list, furnished by the other, which (or the patents to issue on which) it desires to exclude from this agreement; and no licenses are granted by this agreement under any patents so excluded.

#### ARTICLE IV.

##### SCOPE OF LICENSES.

1. All of the licenses herein granted are, unless otherwise expressed in connection with the several grants, licenses to use methods and processes, and to make, use, sell, lease or otherwise



2254

*Plaintiffs' Exhibit No. 40.*

dispose of apparatus and systems in the fields in which the licenses are granted.

2255

2. A license to make apparatus includes a license to have such apparatus manufactured for the licensee by others, except that no rights are granted to either party to manufacture or to have manufactured, under patents under which it receives licenses hereunder, apparatus of the character at the time manufactured by the other party, except in factories owned or operated by one or the other of the parties hereto, or by their subsidiaries, without the written consent of the party granting such licenses.

2256

3. Every license herein granted to either party includes, unless otherwise herein provided, all incidental rights necessary to the full enjoyment and exercise of the license granted, notwithstanding that such incidental rights may lie primarily in a field in which the said party is not herein expressly granted a license.

4. The making, using, selling, leasing or otherwise disposing of parts is subject to the same restrictions and conditions as are applicable under this agreement to apparatus of which they are or may be parts.

## ARTICLE V.

RESERVATIONS AND EXCEPTIONS TO WHICH THE  
LICENSEES ARE SUBJECT.

1. No licenses are granted by either party with reference to the manufacture or sale of wire or

able for the transmission of electric current for light, heat, traction or other power purposes, or for telephone or telegraph purposes.

2. No licenses are granted to the Telephone company for electric lamps or other lighting apparatus (except non-exclusive licenses with reference to telephone and telegraph signal lamps and telephone and telegraph ballast lamps for use solely in fields in which the Telephone company is otherwise licensed under this agreement).

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3. The licenses herein granted to the Telephone company, in so far as they cover rights to sell or lease carrier current, wireless or vacuum tube apparatus for use on electric railroads, are limited to sales or leases of said apparatus to the railroads.

4. Wherever in this agreement either party receives from the other a license with the right to license others, such party shall have the right to license others for past infringement in the fields in which it receives such licenses and to retain for itself all considerations paid to it on account of such past infringements.

2259

## ARTICLE VI.

### LICENSES GRANTED.

Subject to the foregoing reservations, each party grants and agrees to grant to the other the following licenses in the following fields of use:

#### *Government Uses.*

Each party grants to the other non-exclusive licenses to make for, and sell or lease to, the



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United States Government wireless apparatus and systems.

*2. Wireless Telegraphy.*

2261

(a) The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of wireless telegraphy for combined wireless telephone and telegraph sets for use on ships; except that where such combined sets are for use on ocean-going and coast-wise ships of American registry (excluding harbor tug-boats and other harbor craft), said licenses are only to manufacture; and the Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, to use, lease or sell or otherwise dispose of, but not to manufacture such sets. The Telephone Company agrees, upon request, to make such sets and sell them for such use to the General Company upon reasonable terms.

2262

(b) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy to make and use (but not to sell, lease or otherwise dispose of, except to Companies of the Bell System) apparatus and systems for its own communication or that of Companies of the Bell System, and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement, but not for transmission of messages for the public except temporarily in emergencies due to storms or other catastrophes.

(c) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy to make and use (but not to sell, lease or otherwise dispose of, except leases to subscribers in connection with a service given by Companies of the Bell System in this paragraph described) apparatus and systems for the purpose of giving within the continental United States, and between the continental United States and other parts of continental North America, a business, commercial or official service limited to a particular customer or class of customers and analogous to the service given by Companies of the Bell System by wire telegraphy at the date of this agreement, commonly designated as leased wire or special contract service, but said licenses do not include the making or using of such apparatus for (1) transmission or reception for the public generally or (2) transoceanic communication or (3) transmission or reception of programs.

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(d) The General Company grants to the Telephone Company non-exclusive licenses in the field of wireless telegraphy to make and use (but not to sell, lease or otherwise dispose of, except to Companies of the Bell System) apparatus and systems for television for use solely in combination with apparatus and systems for two-way telephony for the purpose of giving a public service combining television and speech, but said licenses do not include the making or using of such apparatus for transmission or reception of programs.

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(e) The General Company grants to the Telephone Company non-exclusive licenses in the



field of wireless telegraphy for combined wireless telephone and telegraph sets, other than sets for transoceanic communication, (1) for use in communication by, with and between airplanes, airships and other automotive devices other than ships and railway vehicles, and (2) for export from the continental United States for use for any purpose other than transoceanic communication.

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(f) The Telephone Company grants to the General Company: (1) exclusive licenses, including the right to grant licenses to others, in the field of wireless telegraphy for purposes of public service communication, subject, however, to non-exclusive rights which the Telephone Company reserves for itself and its present and future subsidiaries under its and their patents to make, use and sell in said field and to grant to the United States Government licenses to make and to have made for it and to use apparatus for such purposes; and (2) non-exclusive licenses, including the right to grant non-exclusive licenses to others, for all other purposes in the field of wireless telegraphy other than the purposes covered by paragraph (a) of this section 2 and by section 8 of this Article VI.

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(g) The General Company grants to the Telephone Company non-exclusive licenses for printing telegraph apparatus for use in the fields of wire and wireless telegraphy.

(h) The Telephone Company agrees that printing telegraph apparatus manufactured by Teletype Corporation (which is a subsidiary of West-

ern Electric Company, Incorporated) shall be sold by Teletype Corporation to the General Company, upon the basis defined in Article X hereof, for use only within the fields for which licenses are herein granted to the General Company. The Telephone Company agrees that Teletype Corporation will grant to the General Company, under patents and inventions owned or controlled by the Teletype Corporation (so far as and to the extent that Teletype Corporation has the right, in view of its existing obligations, to grant such licenses) licenses of the same character and scope as the licenses herein granted by the Telephone Company to the General Company, except that no licenses are agreed to be granted with respect to printing telegraph apparatus under any patents or inventions of the Teletype Corporation; and the General Company agrees that all non-exclusive rights and licenses granted to or reserved by the Telephone Company hereunder may be extended by the Telephone Company to the Teletype Corporation.

2270

(i) The licenses granted to the General Company in this section 2 do not cover the use of wireless telegraph stations for giving a telephone service, except as licensed in section 4 of this Article VI.

2271

### 3. Wire Telegraphy.

(a) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of wire telegraphy for the transmission and reception of programs over



electric light, electric heat, electric power and electric traction lines, subject, however, to the provisions of paragraph (b) of section 5 of this Article VI regarding electrical interference.

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(b) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telegraphy to make (but not to sell, lease or otherwise dispose of) apparatus and systems, and (1) to use such apparatus and systems for its own communication and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement, and (2) to use (but not to furnish to others) such apparatus and systems upon wire telegraph systems owned by it, or leased to it for its operation (other than transoceanic cables), for all purposes other than giving a service by wire telegraphy analogous to the services given by the Companies of the Bell System by wire telegraphy at the date of this agreement, commonly designated as leased wire service, special contract service or teletypewriter exchange service, and other than train dispatching; but no licenses are granted with reference to transoceanic wire telegraphy.

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(c) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telegraphy for apparatus and systems for communication only in connection with the operation of apparatus for power purposes, but not for transmission of messages for the public.

(d) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telegraphy for apparatus and sys-

tems for communication between parts of a train (without regard to the nature of the motive power thereof), or between trains following or approaching each other upon the same system of tracks, or between trains approaching a cross-over or junction point of the systems of tracks upon which they are running, or between trains and signal towers or way-stations within short distances thereof, but in each instance only for use in connection with the operation of such trains but not for train dispatching.

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(c) The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for all purposes in the field of wire telegraphy (other than that covered by paragraph [a] of this section 3) on land, and over ocean cables not more than one hundred miles in length, and between the main body of the United States and Cuba; but no licenses are granted with reference to other transoceanic wire telegraphy.

2277

#### *4. Wireless Telephony.*

##### *A. IN GENERAL.*

(a) The Telephone Company grants to the General Company non-exclusive licenses in the field of wireless telephony to make and use (but not to sell, lease or otherwise dispose of) apparatus and systems for its own communication and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement, but not for transmission of messages



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(as distinguished from programs) for the public except temporarily in emergencies due to storms or other catastrophes.

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(b) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of amateur wireless telephony; and the General Company grants to the Telephone Company non-exclusive licenses to make and sell apparatus in the field of amateur wireless telephony limited as hereinafter in this paragraph (b) provided. The licenses by this paragraph (b) granted by the Telephone Company to the General Company shall be free of royalties, but all apparatus sold by the Telephone Company under the licenses granted by this paragraph (b) shall be treated as if such apparatus were apparatus for one-way wireless telephone reception of programs under the provisions of paragraph (d) of subdivision C of this section and shall be governed by all the provisions of said paragraph (d).

2280

(c) Each party grants to the other non-exclusive licenses for headphones for all purposes in all fields covered by this agreement; provided, however, that headphones sold by the Telephone Company as part of complete apparatus for one-way wireless telephone reception of programs shall be included in the determination of the royalties payable by the Telephone Company under the provisions of paragraph (d) of subdivision C of this section 4.

(d) Each party grants to the other non-exclusive licenses in the field of wireless telephony for apparatus and systems for communication

only in connection with the operation of apparatus for power purposes, but not for transmission of messages for the public.

(c) Each party grants to the other non-exclusive licenses in the field of wireless telephony for apparatus and systems for communication between parts of a train (without regard to the nature of the motive power thereof), or between trains following or approaching each other upon the same system of tracks, or between trains approaching a cross-over or junction point of the systems of tracks upon which they are running, or between trains and signal towers or way-stations within short distances thereof, but in each instance only for use in connection with the operation of such trains but not for train dispatching.

2282

#### B. TWO-WAY WIRELESS TELEPHONY.

(a) The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of two-way transoceanic wireless telephony to make and use (but not to sell, lease or otherwise dispose of) apparatus and systems for use in the continental United States; but such licenses do not include use for transmission or reception of messages offered for telephonic transmission.

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(b) The General Company grants to the Telephone Company non-exclusive licenses in the field of two-way transoceanic wireless telephony, to make and sell to stations outside the conti-



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mental United States engaged in co-operation with the Telephone Company in giving for the public a transoceanic telephone service, apparatus for use in giving such service; and the Telephone Company grants to the General Company non-exclusive licenses including the right to grant non-exclusive licenses to others in the field of two-way transoceanic wireless telephony for apparatus for export from the continental United States.

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(c) The Telephone Company grants to the General Company non-exclusive licenses in the field of two-way wireless telephony for combined wireless telephone and telegraph sets, other than sets for transoceanic communication, (1) for use in communication by, with and between airplanes, airships and other automotive devices other than ships and railway vehicles, and (2) for export from the continental United States for use for any purpose other than transoceanic communication.

2286

(d) The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of two-way wireless telephony (other than in the field of transoceanic wireless telephony) for all purposes other than the purposes covered by subdivision A of this section 4.

(e) The licenses granted to the Telephone Company in this subdivision B do not include the use of wireless telephone stations for giving a telegraph service, except as licensed in section 2 of this Article VI.

**C. ONE-WAY WIRELESS TELEPHONY.**

(a) Each party grants to the other non-exclusive licenses in the field of one-way wireless telephony for apparatus and systems for the purpose of giving a business, commercial or official service limited to a particular customer or class of customers; but the licenses granted by this paragraph (a) do not include the making or using of such apparatus for (1) transmission or reception of messages for the public generally or (2) transmission or reception of programs; and the licenses granted to the Telephone Company with respect to transmission for the purposes covered by this paragraph (a) include only apparatus for the transmission of such service from and within the continental United States.

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(b) Each party grants to the other non-exclusive licenses in the field of one-way wireless telephony for apparatus and systems for use for transmitting for purposes other than covered by paragraph (a) of this subdivision C, including, however, apparatus for wireless telephone reception furnished as a part of the equipment of transmitting stations; but the licenses granted by this paragraph (b) do not include apparatus in the field of amateur wireless telephony.

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(c) The General Company grants to the Telephone Company non-exclusive licenses to make and use (but not to sell, lease or otherwise dispose of, except to Companies of the Bell System) apparatus for one-way wireless telephone reception (including apparatus for the reception



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of programs) for its own communication or that of Companies of the Bell System, and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement.

(d) The General Company grants to the Telephone Company non-exclusive licenses for apparatus for one-way wireless telephone reception of programs; provided, however, that the licenses granted in this paragraph (d) shall be subject to the following terms and limitations:

2291

(1) Tubes (thermionic devices) sold as separate devices for use in apparatus covered by this paragraph (d), or in apparatus which under other provisions of this agreement shall be treated as apparatus covered by this paragraph (d), shall be to the amount of \$1,000,000 free of royalties during each calendar year, and said tubes in excess of said amount in any year shall be subject to a royalty of five per cent. computed as hereinafter provided; but no licenses are granted in this paragraph (d) for tubes in excess of \$2,000,000 in amount or 1,000,000 in number during any calendar year; and provided further that where said tubes are sold as parts of receiving sets or other complete units designed for operation with such sets, such tubes shall be treated as parts of the receiving set or other unit and shall not be classified under this sub-paragraph (1).

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(2) Receiving sets and apparatus which under other provisions of this agreement shall be treated as apparatus covered by this paragraph (d), or parts thereof (including loud speakers,

amplifiers and tubes other than thermionic devices), shall be to the aggregate amount of \$1,500,000 free of royalty in each calendar year, and such sets, apparatus or parts in excess of said amount shall be subject to a royalty of five per cent. computed as hereinafter provided; but no licenses are granted in this paragraph (c) for receiving sets, apparatus and parts in excess of \$3,000,000 in amount in any calendar year, provided, that if the sale of tubes sold as separate devices amount to less than \$2,000,000 during any year, the amount of such deficiency shall be added to the amount of receiving sets, apparatus and parts which may be sold under the license granted in this paragraph (d).

2294

(3) For any portion of the first or last calendar year of this agreement, less than an entire calendar year, during which royalties shall be payable hereunder, the amounts which may be sold free of royalty and subject to royalty respectively shall be those proportions of the amounts which may be sold free of royalty and subject to royalty respectively in the entire calendar year which said fractional part of a calendar year bears to a calendar year.

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(4) The aforementioned amounts sold free of royalty, and the amounts subject to royalty, shall be based on the price at which the apparatus is sold by the manufacturer thereof, before cash discount, freight and advertising allowances or other similar deductions.

(5) Sales for export shall be included in determining the amounts sold free of royalty, and



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the amounts subject to royalty, on the basis of the price at which the sale is made.

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(6) In ascertaining the amount of the sales which are free from royalty and the amount of the sales upon which royalties are to be paid hereunder, where apparatus is sold any part of which embodies any invention of any of the patents in force at the time of such sale under which licenses are granted in this paragraph

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(d), the selling price of the apparatus sold shall be taken as the basis; but apparatus not covered by any of said patents when sold not assembled for operation with apparatus covered by such patents, shall not be taken into account in computing the amount of sales which are free from royalty or the amount of sales which are subject to royalty, unless such apparatus not covered by such patents is adapted for operation with apparatus covered by such patents and is sold in such manner that its sale or its use in connection with apparatus covered by such patents would, except for the licenses granted by this paragraph (d), constitute contributory infringement of the patents under which such licenses are granted. Where radio receiving sets are sold for use in combination with public address apparatus or other apparatus not subject to royalties under this agreement, the sale price of the public address or other apparatus shall not be included in the amount of the sales which are free from royalty or the amount of the sales which are subject to royalty. Chemical primary batteries, wet or dry, and chemical storage batteries, not sold as part of apparatus upon which royalties are payable hereunder, or wiring in a

building in connection with a sale of such apparatus, shall not be taken into account in computing the amount of sales which are free from royalty or the amount of sales which are subject to royalty.

(e) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for apparatus and systems for one-way wireless telephone reception of programs.

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(f) Subdivision A of this section 4 and paragraphs (a) to (e), inclusive, of this subdivision C are intended to make provision for all anticipated fields of use of apparatus for one-way wireless telephone reception. If it should develop that there are other fields of use of such apparatus not covered herein licenses shall be granted in such other fields of use to the respective parties in accordance with the principle underlying said other paragraphs of this subdivision C, with special reference to the interest of the General Company in the field on one-way wireless telephone reception of programs, on the one hand, and of the Telephone Company in the field of one-way wireless telephone reception for giving a service of a business, commercial or official nature, on the other hand. If the parties cannot agree with respect to such licenses, their respective rights shall be determined by arbitration in accordance with the provisions of Article XIII.

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##### 5. Wire Telephony.

(a) The Telephone Company grants to the General Company non-exclusive licenses, includ-



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ing the right to grant non-exclusive licenses to others, and the General Company grants to the Telephone Company non-exclusive licenses, in the field of wire telephony for apparatus for carrier current telephone communication, both one-way and two-way, over electric light, electric heat, electric power and electric traction lines, or partly over such lines and partly across wireless gaps, but in each instance only for the use of the owner or operator of such lines in the business of such owner or operator, and not for transmission of messages for the public except temporarily in emergencies due to storms or other catastrophes.

2303

(b) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of one-way wire telephony for apparatus for the transmission and reception of programs over electric light, electric heat, electric power and electric traction lines including the use of such lines for pick-up lines or for connecting two or more separate electric systems in connection with the transmission or reception of programs over such lines or by means of wireless telephony, but not including the use of other wires for such purposes except as licensed in paragraph (c) of this section 5; provided, however, that no apparatus is licensed under this paragraph (b), or under paragraph (a) of section 3 of this Article VI, the use of which would electrically interfere unreasonably with the Telephone Company's systems of wire communication for which it is licensed under this agreement, as the same may now exist or may

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hereafter normally be developed, or with any system of the Telephone Company for transmitting programs by wire telephony over lines other than electric light, electric heat, electric power and electric traction lines, where such system exists prior to the installation in the same locality by the General Company of apparatus licensed under this paragraph (b), and the Telephone Company shall be the sole judge of the existence of such unreasonable interference. The Telephone Company agrees whenever requested by the General Company, but at the expense of the General Company consented to by it before being incurred, to co-operate with the General Company in every reasonable way to enable the General Company to develop apparatus within the licenses granted by this paragraph (b) which will avoid such electrical interference.

2306

(c) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telephony, both one-way and two-way, to make (but not to sell, lease, or otherwise dispose of) apparatus and systems, and to use such apparatus and systems solely upon systems owned by it, for its own communication and for use solely as an incidental facility in fields in which it is otherwise licensed under this agreement, but not for transmission of messages (as distinguished from programs) for the public except temporarily in emergencies due to storms or other catastrophes. The Telephone Company agrees to furnish to the General Company, when requested, pick-up or connecting wires, if available, for its use in the transmission of programs

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to or from its stations for such transmission either by means of wireless telephony or over electric light, electric heat, electric power and electric traction lines, or for its use in electrical sound recording, on terms at least as favorable as the terms given to others than the General Company, and agrees that in furnishing such pick-up and connecting wires for such service there shall be no discrimination against the General Company.

2309

(d) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telephony for apparatus for the distribution, to an assembled audience, or to rooms within a building or a group of substantially adjacent buildings commonly owned or operated, or to rooms within a ship, airship or train, of matter from apparatus for one-way wireless telephone reception, or from apparatus for reception in the field covered by paragraph (b) of this section 5, or from phonographs, in each case located in the immediate vicinity of such audience or within the building or group of buildings, ship, airship, or train within which such distribution is made.

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(e) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telephony, both one-way and two-way, for apparatus and systems for communication only over wires used in connection with apparatus for remote control or actuation of apparatus for power purposes and only in connection with the operation of apparatus for power purposes, but not for transmission of messages for the public.

(f) The Telephone Company grants to the General Company non-exclusive licenses in the field of wire telephony, both one-way and two-way, for apparatus for communication between parts of a train (without regard to the nature of the motive power thereof), or between trains following or approaching each other upon the same system of tracks, or between trains approaching a cross-over or junction point of the systems of tracks upon which they are running, or between trains and signal towers or way-stations within short distances thereof, but in each instance only for use in connection with the operation of such trains but not for train dispatching.

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(g) The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of wire telephony, both one-way and two-way, for all purposes other than for the purposes covered by the paragraphs (a) and (b) of this section 5; provided, however, that the licenses granted by this paragraph (g) for apparatus for reception of programs in connection with a service of transmitting programs by wire telephony (analogous to wireless broadcasting) over lines other than electric light, electric heat, electric power and electric traction lines, are licenses only to make and use, to lease to subscribers to such a service, and to sell only at retail (except as to sales for export) either directly or through the Telephone Company's own direct agents, and said licenses are subject to the condition that the Telephone Company shall retain in itself, or in one or more of its sub-

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sidaries, title to the apparatus and control of its disposition until it is so sold.

**6. Power Purposes and Household Devices.**

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The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the fields of (a) distance actuation and control by wireless, (b) power purposes (including apparatus for distance actuation and control of apparatus for power purposes and apparatus for indicating at remote points the condition or position, of apparatus for power purposes) and (c) household devices, in each case for purposes other than communication purposes.

**7. Railroad Signalling, Radio Goniometry, X-ray Apparatus.**

2316

(a) The General Company grants to the Telephone Company non-exclusive licenses in the field of radio goniometry for apparatus for use as part of apparatus in respect of which the Telephone Company is otherwise licensed under this agreement.

(b) The General Company grants to the Telephone Company non-exclusive licenses in the field of railway signalling for apparatus incidental to apparatus for train dispatching, for use only by the train dispatcher or similar official for operating at will, and not automatically, signals, switches, brakes and stops.

(c) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to

others, in the fields of railroad signalling, X-ray apparatus and apparatus associated therewith, and radio goniometry.

**8. Train Dispatching.**

The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, in the field of train dispatching.

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**9. Electric Sound Recording.**

(a) The General Company grants to the Telephone Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for electrical apparatus for the production of sound records (which records are for the private use of the maker, and not for commercial use or sale) in combination or connection with apparatus in the field of wire telephony other than in connection with apparatus in the field covered by paragraph (b) of section 5 of this Article VI.

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(b) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for electrical apparatus for the production of sound records (which records are for the private use of the maker, and not for commercial use or sale) in combination or connection with apparatus for one-way wireless telephone reception of programs and with apparatus in the field covered by paragraph (b) of section 5 of this Article VI.



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(c) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for electrical apparatus for the production in homes (which records are for the private use of the maker, and not for commercial use or sale) of sound records of entertainment and educational matter, other than apparatus covered by paragraphs (a) and (b) of this section 9.

2321

(d) The General Company grants to the Telephone Company non-exclusive licenses for electrical apparatus for the production of sound records in homes, for entertainment or educational purposes (which records are for the private use of the maker and not for commercial use or sale), provided that all apparatus sold under the licenses granted in this paragraph (other than that covered by paragraphs [a] and [c] hereof) shall be treated as if such apparatus were apparatus for one-way wireless telephone reception of programs under the provisions of paragraph (d) of sub-division C of Section 4 of Article VI and all of the provisions of said paragraph (d) shall apply thereto.

2322

(e) Each party grants to the other non-exclusive licenses for electrical apparatus for the production of sound records other than apparatus covered by paragraphs (a), (b), (c) and (d) of this section 9.

*10. Electric Phonographs.*

(a) The General Company grants to the Telephone Company non-exclusive licenses, including

the right to grant non-exclusive licenses to others, for electric phonographs for use in combination or connection with apparatus in the field of wire telephony other than in combination or connection with apparatus in the field covered by paragraph (b) of section 5 of this Article VI; provided, however, that the licenses granted by this paragraph (a) for phonographs for private use in homes for entertainment and educational purposes are licenses only to make and use in connection with a service of transmitting programs by wire telephony over lines other than electric light, electric heat, electric power and electric traction lines, to lease to subscribers to such a service, and to sell only at retail (except as to sales for export) either directly or through the Telephone Company's own direct agents, and said licenses are subject to the condition that the Telephone Company shall retain in itself, or in one or more of its subsidiaries, title to the apparatus and control of its disposition until it is so sold.

2324

(b) The General Company grants to the Telephone Company a non-exclusive license for electric phonographs (including electric phonographs in combination or connection with apparatus for wireless telephone reception) for private use in homes for entertainment and educational purposes, other than for the purposes covered by paragraph (a) of section 10 of this Article VI, but all apparatus sold by the Telephone Company under the licenses granted by this paragraph (b) shall be treated as if such apparatus were apparatus for one-way wireless telephone reception of programs under the provisions of

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paragraph (d) of sub-division C of section 4 of Article VI and shall be governed by all of the said provisions of said paragraph (d).

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(c) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for electric phonographs in combination or connection with apparatus for one-way wireless telephone reception, and in combination or connection with apparatus in the field covered by paragraph (b) of section 5 of this Article VI.

(d) The Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for electric phonographs for private use in homes for all entertainment and educational purposes other than those covered by paragraphs (a) and (c) of this section 10.

2328

(e) Each party grants to the other non-exclusive licenses for electric phonographs for all purposes other than those covered by paragraphs (a), (b), (c) and (d) of this section 10.

*11. Apparatus for Co-ordination of Sound and Pictures.*

(a) The rights and licenses of the parties hereto in respect of apparatus for transmitting, receiving, recording or reproducing sound in co-ordination, synchronism, or timed relation with the taking, transmission or projection of pictures shall, in so far as the fields of wire and wireless telegraphy and telephony, electrical sound

recording and electric phonographs are involved, be governed by the other provisions of this agreement relating to said fields.

(b) In so far as apparatus for the taking or projection of pictures and apparatus for co-ordinating, synchronizing or timing such taking or projection in relation to the recording or reproduction of sound are not covered by the provisions of paragraph (a) of this section 11, the Telephone Company grants to the General Company non-exclusive licenses, including the right to grant non-exclusive licenses to others, for such apparatus for private use in homes for entertainment and educational purposes, and each party grants to the other non-exclusive licenses for such apparatus for all other purposes.

(c) The General Company grants to the Telephone Company a non-exclusive license for apparatus for private use in homes for entertainment and educational purposes for the projection of pictures and the reproduction of sound from sound records in co-ordination, synchronism or timed relation therewith, but all apparatus sold by the Telephone Company under the licenses granted by this paragraph (c) shall be treated as if such apparatus were apparatus for one-way wireless telephone reception of programs under the provisions of paragraph (d) of sub-division C of section 4 of this Article VI and shall be governed by all of said provisions of said paragraph (d).

## 2. Public Address Systems.

The Telephone Company grants to the General Company non-exclusive licenses for public

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address systems, including the combination or connection thereof with other apparatus for which the General Company is otherwise licensed hereunder, provided, however, that the licenses granted in this section 12 (1) do not include apparatus for giving by wire telephony a service analogous to wireless broadcasting (but do include apparatus for use in localities specified in paragraph [d] of section 5 of this Article VI), and (2) shall be subject to the following terms

2333 and limitations:

(1) Public address system apparatus and parts thereof shall be to the aggregate amount of \$1,500,000 free of royalty in each calendar year and such apparatus and parts thereof in excess of said amount shall be subject to a royalty of 5% computed as hereinafter provided; but no license is granted for public address system apparatus and parts thereof in excess of \$5,000,000 in amount during any calendar year.

2334

(2) For any portion of the first or last calendar year of this agreement, less than an entire calendar year, during which royalties shall be payable hereunder, the amounts which may be sold free of royalty and subject to royalty respectively shall be those proportions of the amounts which may be sold free of royalty and subject to royalty respectively in the entire calendar year which said fractional part of a calendar year bears to a calendar year.

(3) The aforementioned amounts sold free of royalty, and the amounts subject to royalty, shall be based on the price at which such apparatus

is sold by the manufacturer thereof, before cash discount, freight and advertising allowances or other similar deductions.

(4) Sales for export shall be included in determining the amounts sold free of royalty, and the amounts subject to royalty, on the basis of the price at which the sale is made.

(5) In ascertaining the amount of the sales which are free from royalty and the amount of the sales upon which royalties are to be paid hereunder, where apparatus is sold any part of which embodies any invention of any of the patents in force at the time of such sale under which licenses are granted in this section 12, the selling price of the apparatus sold shall be taken as the basis; but the apparatus not covered by any of said patents, when sold not assembled for operation with apparatus covered by such patents, shall not be taken into account in computing the amount of sales which are free from royalty or the amount of sales which are subject to royalty, unless such apparatus not covered by such patents is adapted for operation with apparatus covered by such patents and is sold in such manner that its sale or its use in connection with apparatus covered by such patents would, except for the licenses granted by this agreement, constitute contributory infringement of the patents under which such licenses are granted. Where public address system apparatus is sold for use in combination with apparatus for one-way wireless telephone reception of programs, the sale price of such receiving apparatus shall not be included in the

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*Plaintiffs' Exhibit No. 40.*

amount of the sales which are free from royalty or the amount of the sales which are subject to royalty. Chemical primary batteries, wet or dry, and chemical storage batteries not sold as part of apparatus upon which royalties are payable hereunder, or wiring in a building in connection with a sale of apparatus shall not be taken into account in computing the amount of sales which are free from royalty or the amount of sales which are subject to royalty. \*

2339

13. *Submarine Signaling, Scientific and Therapeutic Apparatus, Tools and Other Applications.*

Each party grants to the other, non-exclusive licenses in the following fields:

Submarine signaling.

Scientific apparatus for use of laboratories, colleges and scientific societies, as distinguished from commercial use.

2340

Mechanical phonographs.

Wireless apparatus for use of professional investigators (as distinguished from amateurs) for experimental purpose only.

Therapeutic apparatus other than X-ray devices and appliances.

Tools, machinery, appliances, materials, methods and processes for the manufacture, installation and repair of apparatus for use in fields for which the grantee is licensed hereunder.

All applications, not herein otherwise specified, of inventions pertaining or applicable to or to the use of vacuum tubes.

and to generating (directly or from other currents), modifying, amplifying, transmitting or receiving electro-magnetic waves, variations or impulses for other than power purposes.

## ARTICLE VII.

### PROVISIONS WITH REFERENCE TO FOREGOING LICENSES.

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1. Whenever licenses granted under the terms of this agreement are based upon rights held by the licensor under any agreement requiring the payment of royalties or other deferred payments, measured by the use made of the invention, the party accepting such licenses shall make payments measured by its use of the invention at the same rate and upon the same terms as those agreed to be made by the party originally acquiring the rights.

2. Upon the termination of this agreement under the provisions of Article XIV hereof all licenses herein granted shall, during the terms of the several patents, issued or to be issued, in respect of which such licenses exist at the date of termination, continue unaffected and of the same scope and character herein expressed, so far as the grantor thereof has the right to grant such licenses for such terms; and such licenses shall not be limited by the term of this agreement.

2343

3. (a) The Telephone Company may grant sub-licenses to the operating Companies of the



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*Plaintiffs' Exhibit No. 40.*

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Bell System (but not manufacturing companies) which now or may from time to time be giving a communications service.

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(b) Each party hereto may grant to its subsidiaries sub-licenses under the licenses granted to it herein; provided, however, that each subsidiary to which a sub-license shall be granted (excepting, however, sub-licensees pursuant to paragraph (a) of this section 3 and except also the Teletype Corporation as to which special provision is made elsewhere in this agreement) shall either have entered into an agreement with its parent company effectively subjecting to this agreement all United States patents then or thereafter during the term of this agreement owned or controlled by it, or have executed to the party hereto other than its parent company an instrument granting to such other party licenses under said patents co-extensive with the licenses herein granted to such other party. Use by any subsidiary of any sub-license granted under this agreement shall for all purposes of this agreement, including determination of royalties payable hereunder, be deemed to be use by its parent company, and ownership, lease or operation of any telephone or telegraph system or station by any subsidiary shall be deemed to be ownership, lease or operation of such system or station by its parent company for all purposes of this agreement. Wherever in this agreement either party is granted a general right to grant non-exclusive licenses to others such rights shall nevertheless be subject to the provision of this paragraph (b) so far as concerns the grant of sub-licenses to subsidiaries.

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(c) In addition to the sub-licensing provided for in the foregoing paragraphs (a) and (b), each party hereto may assign or grant sub-licenses under any of the rights granted to it hereunder, which are not expressed as including the right to grant sub-licenses to others, provided that in each instance the assent of the other party is first obtained.

(d) When either party shall enter into an agreement with any of its subsidiaries effectively subjecting to this agreement all United States patents then or thereafter during the term of this agreement owned or controlled by such subsidiary, such party shall promptly give the other party appropriate notice of such agreement.

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(e) Each party shall enter into an agreement with each of its subsidiaries which is engaged primarily or wholly in the conduct of research and development work in the fields for which licenses are granted to the other party under this agreement whereby the United States patents owned or controlled by such subsidiary during the term of this agreement shall become effectively subject to this agreement.

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(f) Each party may, subject to the provisions of section 4 of this Article VII, sell or lease to any sub-licensee having a sub-license to use granted under the provisions of any of paragraphs (a), (b) and (c) of this section 3, apparatus for the use of such sub-licensee under such sub-license, notwithstanding that the party granting such sub-license may not be licensed under this agreement generally to sell, lease or otherwise dispose of such apparatus.



2350

Plaintiffs' Exhibit No. 40.

(g) All sub-licenses granted hereunder shall be subject to all limitations and obligations attaching to the apparatus or system in respect of which sub-licenses are granted, whether under the patents, or under the instruments by which any party acquired the patents or licenses under them, or under this agreement.

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(h) No disposition by either party of rights hereunder acquired by it, shall relieve such party of any of its obligations under this agreement, or restrict the rights of the parties hereto in operating under or modifying this agreement.

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4. Each party agrees that, so far as practicable, it will, in disposing of apparatus embodying inventions pertaining or applicable to vacuum tubes, or to generating, modifying, amplifying, transmitting or receiving electro-magnetic waves, or other apparatus or material the unrestricted sale of which would deprive the other party of rights to which it is entitled hereunder, use such precautions by contracts, leases, restricted licenses or otherwise as may be necessary or advisable in order to prevent its subsidiaries, sub-licensees, customers or others from acquiring (by acquisition of apparatus from it or otherwise) licenses to use the same which the party disposing thereof has no right to grant.

5. All royalties payable under any provision of this agreement shall continue to be payable to the ends of the terms of the patents in respect of which such royalties are payable, notwithstanding any termination of this agreement.

6. The admission of validity implied in the acceptance of licenses hereunder is limited to the field for which such licenses are granted or agreed to be granted.

7. No licenses under foreign patents are now granted or are to be implied; but except as herein otherwise expressly provided the licenses to make, sell, lease or otherwise dispose of, herein granted under United States patents include the right to make, sell, lease or otherwise dispose of for use abroad in the fields for which such licenses under United States patents are granted, but not for use abroad in other fields. Each party agrees not to export to any country in which the other party has an affiliated company, apparatus purchased from such other party which such other party could not itself so export, in view of existing contract obligations, after notice of such obligations and without first securing a written waiver thereof.

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8. Each party represents that in its best judgment it has no outstanding obligations which would prevent it from entering into the agreements and from granting the licenses herein expressed. If, however, it is found that there are such conflicting obligations, the present agreement is made subject to the right to fulfil those obligations.

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## ARTICLE VIII.

### INTERFERENCES.

The parties agree to use reasonable endeavors to settle, without litigation, interferences now pending or which may arise involving inventions within the scope of this agreement.



**ARTICLE IX.****CO-OPERATION AND EXCHANGE OF INFORMATION.**

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1. Each party agrees that it will, from time to time during the term of this agreement, freely permit the other to have all information in its possession which it may have a right to dispose of with reference to its standardized apparatus or methods or processes applicable to the uses of the other party in fields in which such other party is granted licenses hereunder, but any secret process so disclosed shall be maintained in secrecy by the party to whom it is disclosed. Blue prints, etc., shall be furnished at the cost of preparing the same. For the purpose of acquiring such information each party shall at all reasonable times have access (through a reasonably limited number of accredited representatives who are regular employees under obligation to assign inventions to their employers), to the laboratories, factories and wireless stations of the other, to the end that development work may be expedited and rendered the more effective.

Each party shall, with reference to inventions owned or controlled by it, under which the other party is entitled to rights hereunder and which either party deems to be of sufficient value to and aid the other to obtain proper patents thereon.

2. Each party shall afford the engineering representatives of the other the fullest possible facilities, consistent with the reasonable operation of the other, for experimenting and for develop-

ing and testing apparatus and systems for use in transoceanic telephony, and each shall at all times be given such an opportunity to make such tests, experiments and observations in the transoceanic stations of the other as do not conflict with the service then being rendered by such stations, and each party shall afford to the other such facilities for test, experimentation and observations on ships as it may be able to extend.

3. In the operation of wireless and carrier-current communication, the parties shall co-operate to the end that interference with the operations of either party, due to the operations of the other, shall be minimized, it being recognized that the available wave lengths are limited.

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## ARTICLE X.

### PURCHASES AS BETWEEN PARTIES.

It is recognized that each party has and will normally continue to have facilities for manufacturing certain apparatus or parts thereof which may be required by the other party under its licenses hereunder, and that a duplication of such facilities may be wasteful and uneconomical. Each party agrees that it will upon request manufacture for and sell and deliver to the other, with reasonable business promptness and within its reasonable manufacturing capacity, on receipt of orders from time to time, and at favorable prices not to exceed those charged to others (except subsidiaries and, in the case of the Telephone Company, Companies of the Bell System) purchasing in like quantities for use in the

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*Plaintiffs' Exhibit No. 40.*

United States, such apparatus and parts as the former is engaged in manufacturing from time to time and as the latter may desire for use in the fields for which licenses are granted to it by this agreement.

## ARTICLE XI.

## LITIGATION.

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1. Neither party shall bring suit for infringement of patents against the other party, or against the distributors and jobbing houses owned by or affiliated with either party, because of sales by such party, or by its (or its subsidiaries') distributors or jobbing houses, of apparatus made in the United States, by others than the parties hereto, it being agreed that the remedy in case of any such infringement shall be only by suit against the manufacturer of those devices; but nothing herein contained shall be construed as the granting of a right to sell infringing apparatus manufactured by others.

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2. In all cases of infringement of a patent of either party in a field in which the licenses herein granted to the other party include the general right to grant sub-licenses, if the party holding title to such patent shall not bring suit against the infringer within thirty days after receipt from the other party of written notice and full information of such infringement together with a written offer from such other party to pay half the cost and expenses of such suit, then (a) the party having given such notice, information and offer may at its own expense bring suit against the infringer in question in the name of the party holding legal title to the patent, and

(b) such party holding title to the patent shall assign to the other party all claims, demands and rights of action against the particular infringer designated in such notice on account of any and all past and future infringements of such patent in said field.

3. If, however, the party holding title to such patent shall bring suit against the infringer within thirty days after receipt of said notice and information from the other party, then any recoveries from the infringer shall be applied first toward the reimbursement of the costs and expenses of such suit, and the remainder, if any, shall be divided between the parties as their interests appear. In any such case the party holding title to the patent in suit shall not release or license the infringer or otherwise settle or dismiss the suit without the consent of the party having the general right to grant sub-licenses.

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## ARTICLE XII.

### RELEASES.

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Each party reserves to itself the right to deal with the United States Government with reference to settlement for past use of its inventions in telephone and telegraph apparatus and systems. Subject to the foregoing, each party releases the other and the vendees and users of apparatus or systems made by it, from all claims growing out of past infringement of patents, by reason of the manufacture, use and sale of such apparatus and systems by the other party, and its resale or use by such vendees and users.



**ARTICLE XIII.****ARBITRATION.**

2369 In case any controversy under this agreement (except in respect of interference or priority of rights to inventions or patents) shall arise between the parties to this agreement, which they are unable to adjust between themselves, it shall be settled by arbitration pursuant to the Arbitration Law of the State of New York in the following manner:

2370 Either party may by notice in writing served on the other, appoint one arbitrator and call upon the other to appoint a second arbitrator within thirty days after the receipt of such notice; and each party agrees that upon receiving any such notice it will so appoint an arbitrator. The two arbitrators thus appointed shall, within thirty days after the appointment of the one last appointed, jointly appoint a third arbitrator. The controversy shall be submitted to the three arbitrators in such manner as they shall direct and their decision, or the decision of a majority of them, rendered in writing, shall be final, conclusive and binding upon the parties. In the event that a second arbitrator shall not be appointed as above provided or the two arbitrators first appointed shall fail to appoint a third, application may be made by either party to the Supreme Court of the State of New York, or to a judge thereof, to designate and appoint an arbitrator or arbitrators, as the case may require, as provided by said Arbitration Law. Each party shall pay its own expenses in connection with the arbitration but the compensation

and expenses of the arbitrators shall be borne in such manner as may be specified in their decision in writing.

#### ARTICLE XIV.

##### TERMINATION OF AGREEMENT.

This agreement shall continue until December 31, 1954, but shall automatically continue thereafter until cancelled on three years' written notice given after December 31, 1951, by one party to the other party.

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#### ARTICLE XV.

##### FURTHER ASSURANCES.

The parties agree to execute and deliver such further instruments as may reasonably be necessary for carrying out the provisions and purposes of this agreement.

#### ARTICLE XVI.

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##### SUCCESSORS.

This agreement is binding upon and shall inure to the benefit of each of the parties hereto and their several successors in business, except that either party may transfer or dispose of any part or parts of its business not involving the grant of any licenses under this agreement, and in such case this agreement shall not be binding upon or inure to the benefit of the successor to that part of the business so transferred.



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Plaintiffs' Exhibit No. 40.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed on the day and year first above written, by their proper officers thereunto duly authorized.

GENERAL ELECTRIC COMPANY,  
(Sgd.) By CHARLES W. APPLETON,  
Vice-President.  
O. K. A. G. D.  
[SEAL]

2375

Attest:

(Sgd.) J. W. LEWIS  
Asst. Secretary.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY,  
By (Sgd.) WALTER S. GIFFORD,  
President.  
G. E. F.  
C. M. B.

2376

Attest:

(Sgd.) A. A. MARSTERS,  
Secretary.

[SEAL]

Plaintiffs' Exhibit No. 41.

DISTRICT COURT OF THE  
UNITED STATES,

DISTRICT OF DELAWARE.

UNITED STATES OF AMERICA,  
Petitioner,

against

RADIO CORPORATION OF AMERICA,  
GENERAL ELECTRIC COMPANY,  
INTERNATIONAL GENERAL ELECTRIC  
COMPANY, WESTINGHOUSE  
ELECTRIC & MANUFACTURING  
COMPANY, WESTINGHOUSE  
ELECTRIC INTERNATIONAL COM-  
PANY, NATIONAL BROADCASTING  
COMPANY, INC., R. C. A. COM-  
MUNICATIONS, INC., R. C. A.  
PHOTOPHONE, INC., R. C. A.  
RADIOTRON COMPANY, INC.,  
R. C. A. VICTOR COMPANY,  
INC., AMERICAN TELEPHONE  
AND TELEGRAPH COMPANY,  
WESTERN ELECTRIC COMPANY,  
INC., GENERAL MOTORS COR-  
PORATION and GENERAL MOTORS  
RADIO CORPORATION,  
Defendants.

In Equity  
No. 793.

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STIPULATION

Referred to in Consent Decree  
of November 21, 1932

1. The petitioner asserts that the matters and  
facts alleged in its Amended and Supplemental



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*Plaintiffs' Exhibit No. 41.*

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- Petition are true and that by means thereof the defendants have violated the Anti-Trust Laws of the United States as charged in said Petition. The defendants maintain the truth of their answers in this cause and assert that they have not violated the Anti-Trust Laws in fact or intent, but that they desire to avoid the economic waste and business disorganization necessarily involved in continuing this litigation, and are willing that a consent decree in the form attached hereto and made a part hereof, be entered herein without conceding or admitting the truth of the facts or matters alleged by the petitioner and without any findings of fact, provided that such consent on their part and the entry of the decree shall not constitute or be considered an admission, and that the entry of such decree or the decree itself shall not be or be considered an adjudication, that they have violated any law of the United States. To such proviso the petitioner assents, because the attached form of decree will provide suitable relief concerning all matters charged in the Petition and not reserved for later determination, and renders an adjudication unnecessary.
- 2381
- 2382

2. This cause may be dismissed as to American Telephone and Telegraph Company and Western Electric Company, Inc., who have this day filed their Second Supplement to their answer together with "Substitute License Agreement (B2) and Agreements Relating Thereto" dated July 1, 1932; and may be dismissed as to General Motors Corporation and General Motors Radio Corporation, the last named corporation having gone out of business and the agreements

between General Motors Radio Corporation and defendants, specified in the Petition having been abrogated.

3. General Electric Company and Westinghouse Electric & Manufacturing Company represent that they propose voluntarily to divest themselves of their holdings of stock of Radio Corporation of America by distribution ratably among their own respective stockholders (who, in each case, are very numerous) or otherwise; but they are unwilling to disassociate themselves from participation in the activities of Radio Corporation of America; and the last named company is unwilling that they should do so, unless such arrangements may be made that Radio Corporation of America is left in what is deemed to be a reasonably sound position, financially and otherwise. Said Companies and the Radio Corporation of America believe that this has been done, the said Companies having made arrangements with the Radio Corporation of America, acting through its directors other than those of its directors who are connected also with General Electric Company and Westinghouse Electric & Manufacturing Company, that its debts and its real estate commitments shall be substantially reduced as set forth in the attached "Basic Agreement" of even date herewith; that the license relations between the parties be changed from the existing ones to those set forth in the attached "Agreement A-1," and "Memorandum on Foreign Situation," of even date herewith, between Radio Corporation of America, General Electric Company and Westinghouse Electric & Manufacturing Company

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*Plaintiffs' Exhibit No. 41.*

and that General Electric Company and Westinghouse Electric & Manufacturing Company enter into certain agreements, hereto attached, with National Broadcasting Company, Inc., with reference to their broadcasting stations.

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It is agreed that it is fair and equitable that periods shall be provided as specified in said consent decree for putting those changes into effect and that the provisions there contained relating thereto are proper. Letter-Agreements (C-1) to (C-5) inclusive between the parties dealing with operations in said periods are exchanged between them.

The petitioner, by its Department of Justice, has examined all of the Agreements attached hereto, and also the above-mentioned Substitute License Agreement (B2) and Agreements Relating Thereto, and finds no objection to them.

2388

4. Among the Agreements of which the petitioner has complained are various contracts with foreign companies and governments, and the petitioner in its Amendment to its Amended and Supplemental Petition complains also of the defendants' contention such as that made in a certain Czechoslovakian arbitration. It is recognized that said contention and that all of said contracts with foreign companies and governments present special situations with which the defendants should be afforded an opportunity to deal by negotiation or otherwise. The petitioner, accordingly, does not ask that the decree shall deal with them now, it being agreed that consideration of them be reserved as provided in the attached form of decree.

5. It is agreed that a consent decree, in the form hereto attached, may be entered.

November 21, 1932.

UNITED STATES OF AMERICA  
By WILLIAM D. MITCHELL  
Attorney General of the United States

JOHN LORD O'BRIEN  
Assistant to the Attorney General  
of the United States

2390

WARREN OLNEY, JR.  
ROBERT L. LIPMAN  
HAMMOND E. CHAFFETZ,  
Special Assistant to the Attorney General

RADIO CORPORATION OF AMERICA  
NATIONAL BROADCASTING COMPANY, INC.  
R. C. A. COMMUNICATIONS, INC.  
R. C. A. PHOTOPHONE, INC.  
R. C. A. RADIOTRON COMPANY, INC.  
R. C. A. VICTOR COMPANY, INC.

by CHAS F. CUNLEY  
Solicitor and of Counsel 2391

CHARLES NEAVE  
MANTON DAVIS  
STEPHEN PHILBIN  
of Counsel

GENERAL ELECTRIC COMPANY  
INTERNATIONAL GENERAL ELECTRIC COMPANY

by CHAS F. CUNLEY  
Solicitor and of Counsel

THURLOW M. GORDON  
DARIUS E. PRICK  
of Counsel



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Plaintiffs' Exhibit No. 42.

WESTINGHOUSE ELECTRIC & MANUFACTURING  
COMPANY

WESTINGHOUSE ELECTRIC INTERNATIONAL  
COMPANY

by CHAS F. CURLEY  
Solicitor and of Counsel

ROBERT T. SWAINE  
WILLIAM D. WHITNEY  
of Counsel

2393

Plaintiffs' Exhibit No. 42.

IN THE  
DISTRICT COURT OF THE UNITED  
STATES,

FOR THE DISTRICT OF DELAWARE.

2394

UNITED STATES OF AMERICA,  
Petitioner,  
against  
RADIO CORPORATION OF AMERICA,  
et al.,  
Defendants.

In Equity  
No. 793.

ORDER OF DISMISSAL.

The petitioner by its counsel having moved  
that the above entitled cause be dismissed as  
to the defendants American Telephone & Tele-  
graph Company, Western Electric Company,

Inc., General Motors Corporation and General Motors Radio Corporation, and it appearing that

(1) Since the filing of the Amended and Supplemental Petition herein the agreements therein complained of between defendants American Telephone & Telegraph Company and Western Electric Company, Inc., on the one side, and others of the defendants on the other side, have been modified so as to eliminate therefrom the provisions thereof which said Petition asserted to be unlawful and by reason of which relief was sought against said two defendants, and

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(2) Since the filing of said Petition the defendant General Motors Radio Corporation has been dissolved and the agreements complained of in said Petition between the defendants General Motors Corporation and General Motors Radio Corporation and between said defendants and other of the defendants have been abrogated.

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Now, therefore, it is hereby ordered that said cause be dismissed as to said defendants American Telephone & Telegraph Company, Western Electric Company, Inc., General Motors Corporation and General Motors Radio Corporation.

Done in open court this 21st day of November, 1932.

JOHN P. NIELDS  
District Judge.



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**PAGE**

(1)  
Dec 18 1912

Efficiency of the Audion

Let  $I_p$  = D.C. plate to filament,  $I_p(ac)$  = a.c. cur.  
 $I_g$  = D.C. grid to filament  $I_g(ac)$  = " "  
 $E_p$  = Voltage plate to filament  $E_p(ac)$  = A.C. Potential  
 $E_g$  = " grid to filament  $E_g(ac)$  = " "  
 $R_p$  = Resistance plate to filament  $R_p(ac)$  = A.C. Resist.  
 $R_g$  = " grid to filament  $R_g(ac)$  = " "  
 $m, \mu, A, A_0$  = Constants for individual Audions  
determined by curves on D.C. tests

$A, \mu$  = variable function of  $V_g + V_p$

Input Impedance  $m$  (from curves)  $\left\{ \begin{array}{l} \text{Audion-7A} \\ I_g = 8 V_e^{1.22} \end{array} \right.$

(1)  $I_g = A_0 E_g^m$

$R_{g(ac)} = \frac{d E_g}{d I_g (m-1)}$  (approximately)

(2) From (1)  $R_{g(ac)} = \frac{E_g}{m A_0 E_g^{m-1}}$

$R_{g(ac)} = \frac{E_g}{m A_0}$

But from the curves it is assumed that the current perfectly rectified, is only the positive  $\frac{1}{2}$  of the current flow so that:

(3) The apparent  $R_{g(ac)} = \frac{2 E_g (r.m.s.)}{m A_0}$

Input voltage =  $E_g(ac)$   $E_g(ac) = .707 E_g(r.m.s.)$

Input Energy =  $\frac{E_g^2}{2 R_{g(ac)}} = \frac{E_g^2 m A_0}{2 E_g^2}$

$= \frac{.707 E_g^2 m A_0}{2 E_g^2}$  (m + 1) Page 43

Input Energy =  $\frac{.707 m A_0 E_g^2}{2}$

650-175



Output Impedance

$$I_p = A E_p^n$$

$$R_{pex} = \frac{dE_p}{dI_p}$$

$$R_{pex} = \frac{E_p^{1-n}}{n A}$$

from curves  $\left\{ \begin{array}{l} \text{Audion 7A} \\ I_p = \frac{4.15(V_p)^{1.7}}{V_p + 30} E_p^{1.7} \end{array} \right.$   
 where  $A$  and  $n$  are functions of  $V_p$   
 approximately 0 and  $V_p$

Output Energy

With  $R_{ext} = 0$

$$\text{Energy} = \frac{E_{max}^2}{R_{pex} + R_{ext}} = \frac{E_p^2}{R_{pex}} \quad (\text{all unavailable})$$

With  $R_{ext} = R_{int}$

$$\text{Energy} = \frac{E_p^2}{2 R_{pex}} \quad \frac{1}{2} \text{ of which is unavailable}$$

$$\text{Available Energy} = \frac{E_{pmax}^2}{4 R_{pex}}$$

$$\text{Energy} = \frac{R_{pex} I_{pmax}^2}{4 n A} \quad (U-n)$$

To obtain  $I_{p(ac)}$

Let change of current due to reversing grid volts  $E_g$  be called  $\Delta I_p$

$$\Delta I_p = f_1(E_g) \quad \text{from curves } \left\{ \begin{array}{l} \text{For 7A Audion} \\ \Delta I_p = (3 E_p + 20) E_g \end{array} \right.$$

$$I_{p(ac)} = \frac{1}{\sqrt{2}} \frac{\Delta I_p}{E_g} \quad E_{g(ac)} = 0.707 E_g$$

$$I_{p(ac)} = \frac{1}{\sqrt{2}} f_1(E_{p(ac)})$$

$$\therefore \text{Output Energy} = \frac{1}{4} \left[ \frac{1}{\sqrt{2}} f_1(E_{p(ac)}) \right]^2 \frac{1}{n A} E_p^{(U-n)}$$

$$\text{Efficiency} = \frac{2 E_p^{(U-n)} \left[ f_1(E_{p(ac)}) \right]^2}{7.07 n A E_{g(ac)}}$$

$$Eff. = \frac{2 E_p^{(1-n)} [f_1(E_{g+1})]^2}{.707 \sqrt{1+n} m A A_0 E_{g+1}^{n+1}}$$

$$f_1(E_{g+1}) = (3 E_k + 20) E_{g+1}$$

$$A_0 = 8$$

$$m = 1.22$$

$$A = \log^{-1} \left( \frac{4.15(V_k + 1)}{V_k + 70.5} \right)$$

$$n = \frac{55.2}{V_k + 70.5}$$

For Audion 7-A

$$\therefore Eff. = \frac{(3 E_k + 20)^2}{55.2 \left( \frac{55.2}{V_k + 70.5} \right) E_k^{(n+1)} E_k^{.22} \log^{-1} \left[ \frac{4.15(V_k + 1)}{V_k + 70.5} \right]}$$

$$E_k = \frac{12100}{55.2 \left( \frac{55.2}{70.5} \right) 30^{(1.11+1)} \cdot 8^{.22} \log^{-1} \left[ \frac{4.15(6.1)}{70.5} \right]}$$

$$\frac{12100 \cdot 1.66}{96.2 \cdot 12.34 \cdot 1.41} = \underline{\underline{16.9}}$$

$$E_k = \frac{12100}{55.2 \left( \frac{55.2}{71.3} \right) 30^{(1.11+1)} \cdot 8^{.22} \log^{-1} \left[ \frac{4.15(6.1)}{71.3} \right]}$$

$$= \frac{12100}{93.8 \cdot 30^{(0.7)} \cdot 8^{.22} \log^{-1} .239}$$

$$= \frac{12100 \times 1.05}{9.38 \times 10.8 \times 1.73} = \underline{\underline{7.25}}$$

2. Sub 13) 5.4

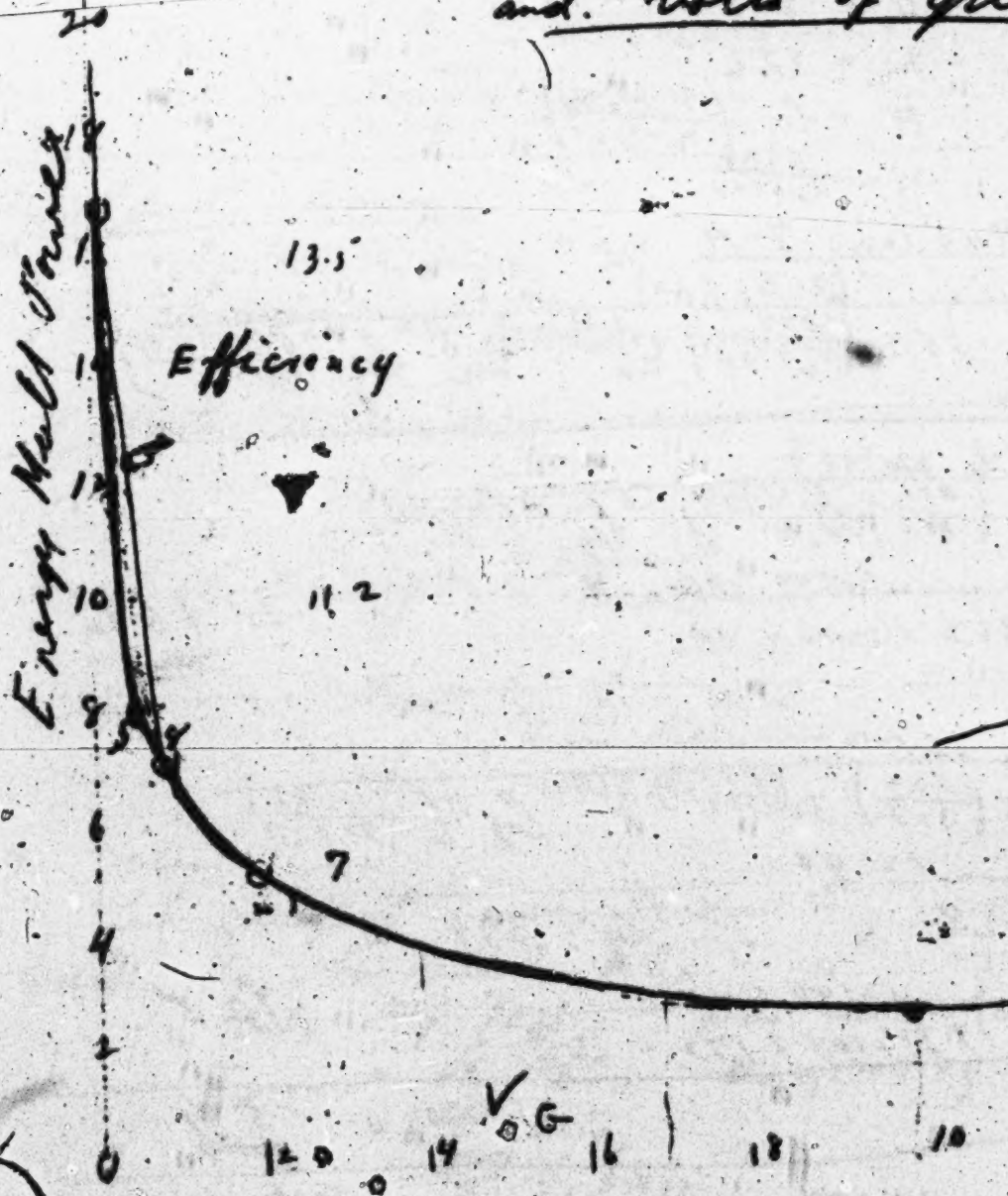
$$E_k = \frac{12100}{55.2 \left( \frac{55.2}{10+70.5} \right) 30^{(1.11+1)} 10^{.22} \log^{-1} \left( \frac{4.15(11)}{40.5} \right)}$$

$$= \frac{72.5 \cdot 30^{(0.12)} \cdot 10^{(.22)} \log^{-1} 1.126}{72.5 \cdot 2.9 \cdot 1.66 \cdot 13.4} = \underline{\underline{2.59}}$$



Relation between Efficiency  
or Energy Multiplier Power  
and Volts of grid.

1.204



11.2 log R.

$$\boxed{Eff = f(E_p)}$$

$$Eff = \frac{(3E_p + 20)}{55.2 \left( \frac{53.2}{V_p + 10.5} \right) E_p^{\left( \frac{53.2}{V_p + 10.5} - 1 \right)} E_p^{\log \left( \frac{4.15(V_p + 10.5)}{V_p + 10.5} \right)}}$$

Let  $V_p = .5 \text{ volt}$

$$Eff = \frac{(3E_p + 20)}{94.6 E_p^{0.71} \cdot 857 \cdot 1.54} = \frac{(3E_p + 20)}{129 E_p^{0.71}}$$

Cal:

$V_p = 30$

$$\frac{121.00}{129 \cdot 10^{0.71} \cdot 857 \cdot 1.54} = \frac{121.00}{129 \cdot 10^{0.71} \cdot 857 \cdot 1.54} = 8.28$$

$V_p = 10$

$$\frac{25.00}{129 \cdot 10^{0.71} \cdot 857 \cdot 1.54} = \frac{25.00}{129 \cdot 10^{0.71} \cdot 857 \cdot 1.54} = 3.78$$

$V_p = 50$

$$\frac{289.00}{129 \cdot 50^{0.71} \cdot 857 \cdot 1.54} = \frac{289.00}{129 \cdot 50^{0.71} \cdot 857 \cdot 1.54} = 13.88$$

Energy Multiplier Factor

Efficiency

Volts. B. Battery





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**PAGE**

## PLAINTIFF S' EXHIBIT No. 44.

Page 190 of Pierce's Notebook No. 20.

Oct-2, 1913

Audion A-7.1

Effect of  $E_c$ 

$I_f$	$E_f$	$E_b$	$E_c$	Gain	$I_a$	Remarks
1.35	27	40	0	24	370	Blue haze in all cases
"	"	49.5	1.55	23	710	
"	"	453	"	19	700	
"	"	545	"	19	860	
"	"	63	"	18	920	
"	"	50	4	9	820	
"	"	40	"	8	600	
"	"	60	"	8	900	
"	"	50	5.5	-8	870	
"	"	40	"	-3	740	
"	"	30	"	+3	540	
"	"	20	"	6	400	
"	"	60	"	-8	800	

Gain Audion to Thomsen

Oct. 2, 1913

New Audions made Sept 30 + Oct 1st.

No	Coat.	Max. Cur. on pump	
<u>35</u>	Heavy Ta	15	Grid nearest filament
<u>36</u>	"	15	Grid nearest Plates
<u>37</u>	"	15	Grid half way betw plate + fil.
<u>38</u>	Ba Res.		Burnt out on pump
<u>39</u>	Heavy Ta	1.55 amp	Loop Grids of different sizes.
<u>40</u>	Ba Res.	2.65 amp	(Kukumoto) same as 39.



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**PAGE**

Page 55 of Notebook No. 36

# AUDION 39

## DESCRIPTION.



A = B = PLATE

C = GRID

(composed of a wire-loop  
with no network between)

D = GRID

(Like C but some  
what smaller)

F = FILAMENT.

(Heavy Tantalum)





16

12/15/43

Tubes received 12/15, 2Pm

Heiden Fil. Coating

No. 155 (Heiden) Sr(OH) + Ba Res + Sr(OH) + Ba Res.  
157 " " " " " "  
158 " " Ba Res.

Pump Record  
Timing pump = 2.6 hours  
Max I<sub>f</sub> = 1.7 amp  
Vacuum = 75.93  
Heat = 463° F for 5 min  
Filaments glow 45 min

Blue haze on #155 at 110V.  
(crack in squash)

#158 (special)

12/15  
ES-111724

Pt. Turb. Ba Res - K

Time. E<sub>f</sub>. I<sub>f</sub>. E<sub>c</sub>. E<sub>g</sub>. I<sub>g</sub>. Gain. Remarks

(Side A + Side B)

3.25	2.65	1.5	0	40	2	open
				55	25	
				70	50	0
				85	75	
				100	97	
	1.4			40	30	
				55	57	
				70	83	
				85	103	
				100	119	
	2.75			40	62	
				55	87	
				70	108	
				85	124	
				100	137	

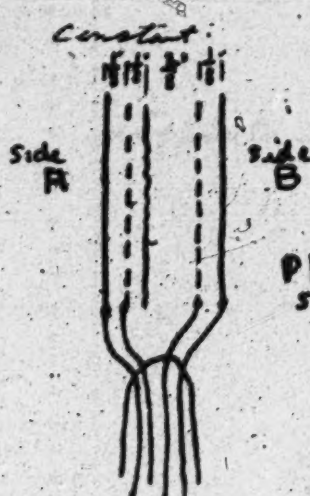


Plate + grid + bulb  
size - standard  
sec. 6.

(Side A)

3.25	2.65	1.5	0	40	1	open
				55	10	
				70	24	
				85	43	
				100	63.5	
	1.4			40	13	
				55	28	
				70	47	
				85	65	
				100	82	
	2.75			40	32	
				55	52	
				70	70	
				85	88	
				100	98	



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**PAGE**

*Circuit #2*

<i>Exp. Time</i>	<i>E<sub>p</sub></i>	<i>I<sub>p</sub></i>	<i>E<sub>p</sub></i>	<i>I<sub>p</sub></i>	<i>E<sub>p</sub></i>	<i>I<sub>p</sub></i>	<i>Remarks</i>
<i>1/5</i>	<i>1.25</i>	<i>0</i>	<i>10</i>	<i>8.</i>	<i>2.5</i>	<i>170</i>	<i>Small Cherry Red</i>
			<i>25</i>	<i>170</i>			
			<i>40</i>	<i>230</i>			
			<i>55</i>	<i>240</i>			
			<i>100</i>	<i>240</i>			
<i>2.3</i>	<i>1.25</i>	<i>0</i>	<i>15</i>	<i>145</i>			
			<i>30</i>	<i>400</i>			
			<i>45</i>	<i>2150</i>			
			<i>60</i>	<i>3350</i>			
			<i>75</i>	<i>4500</i>			
			<i>100</i>	<i>5400</i>			<i>dropped to 4500 Blueberry</i>
<i>1/6 10</i>	<i>2.35</i>	<i>1.25</i>	<i>0</i>	<i>10</i>	<i>50</i>		<i>One life &amp; 1.4 amp.</i>
			<i>0</i>	<i>155</i>	<i>200</i>		<i>for 10 hrs.</i>
			<i>0</i>	<i>205</i>	<i>420</i>		
			<i>0</i>	<i>26</i>	<i>765</i>		
			<i>0</i>	<i>30</i>	<i>1080</i>		
			<i>0</i>	<i>35</i>	<i>1510</i>		
			<i>0</i>	<i>50</i>	<i>2000</i>		
			<i>0</i>	<i>65</i>	<i>4500</i>		
			<i>0</i>	<i>80</i>	<i>5700</i>		
<i>2.8</i>	<i>1.4</i>	<i>0</i>	<i>100</i>	<i>6100</i>			<i>dropped to 5700</i>
			<i>0</i>	<i>10</i>	<i>50</i>		
			<i>0</i>	<i>245</i>	<i>830</i>		
			<i>0</i>	<i>40</i>	<i>2420</i>		
			<i>0</i>	<i>55</i>	<i>4100</i>		
			<i>0</i>	<i>70</i>	<i>5450</i>		
			<i>0</i>	<i>85</i>	<i>8200</i>		
			<i>0</i>	<i>100</i>	<i>10500</i>		
<i>2.8</i>	<i>1.4</i>	<i>1.4</i>	<i>10</i>	<i>170</i>			
			<i>1.4</i>	<i>25</i>	<i>1065</i>		
			<i>1.4</i>	<i>40</i>	<i>2800</i>		
			<i>1.4</i>	<i>55</i>	<i>4600</i>		
			<i>1.4</i>	<i>70</i>	<i>6600</i>		
			<i>1.4</i>	<i>85</i>	<i>8800</i>		
			<i>1.4</i>	<i>100</i>	<i>11100</i>		
<i>2.8</i>	<i>1.4</i>	<i>2.8</i>	<i>10</i>	<i>170</i>			
<i>2.8</i>	<i>1.4</i>	<i>2.8</i>	<i>25</i>	<i>1065</i>			
			<i>10</i>	<i>235</i>			
			<i>25</i>	<i>1215</i>			
			<i>40</i>	<i>3850</i>			
			<i>55</i>	<i>4900</i>			
			<i>70</i>	<i>6900</i>			
			<i>85</i>	<i>9100</i>			
			<i>100</i>	<i>11500</i>			
<i>2.8</i>	<i>1.4</i>	<i>0</i>	<i>25</i>	<i>840</i>			<i>19</i>
			<i>40</i>	<i>2450</i>			<i>21</i>
			<i>55</i>	<i>4100</i>			<i>22</i>
			<i>70</i>	<i>6050</i>			<i>22</i>
			<i>85</i>	<i>8200</i>			<i>22</i>
<i>2.8</i>	<i>1.4</i>	<i>1.4</i>	<i>25</i>	<i>1030</i>			<i>18</i>
			<i>40</i>	<i>2700</i>			<i>21</i>
			<i>55</i>	<i>4500</i>			<i>21</i>
			<i>70</i>	<i>620</i>			<i>18</i>



Cushion #235 continue from P. 55

Sept. 1911	$E_1$	$I_1$	$E_2$	$I_2$	$I_{\text{sum}}$	Remarks.
	2.5	1.5	0	25	150	19
	2.8	1.9	0	40	450	23
	2.8	1.4	0	55	1050	25
	2.8	1.4	0	70	1200	27
	2.8	1.4	0	86	2300	27
	2.8	1.4	0	100	2300	27
	2.8	1.4	0	85	2000	27
	2.8	1.4	1.4	26	250	27
	2.8	1.4	1.4	40	150	24
	2.8	1.4	1.4	55	1340	27
	2.8	1.4	1.4	70	2300	27
	2.8	1.4	1.4	85	3000	25
	2.8	1.4	2.0	26	250	20
	2.8	1.4	2.0	40	400	24
	2.8	1.4	2.0	55	1300	24
	3.1	1.5	0	25	125	15
	3.1	1.6	0	40	350	21
	2.8	1.4	0	40	440	23

$E_2$  value not correct

1/3 2

After impedance tests by Math.

2.06	1.44	0.00	65	1.00	1.00
2.06	1.44	0.00	70	0.00	0.00
2.06	1.44	1.44	36	0.00	0.00
2.06	1.44	1.44	70	0.00	0.00
2.06	1.44	1.44	00	0.00	0.00

County of \_\_\_\_\_

2-28	1-1	1-1	50	2500	24
2-28	1-1	1-1	70	1000	25
2-28	1-1	1-1	70	1000	24
2-28	1-1	1-1	100	1000	27

Sub. 2 - 1948

[illegible]

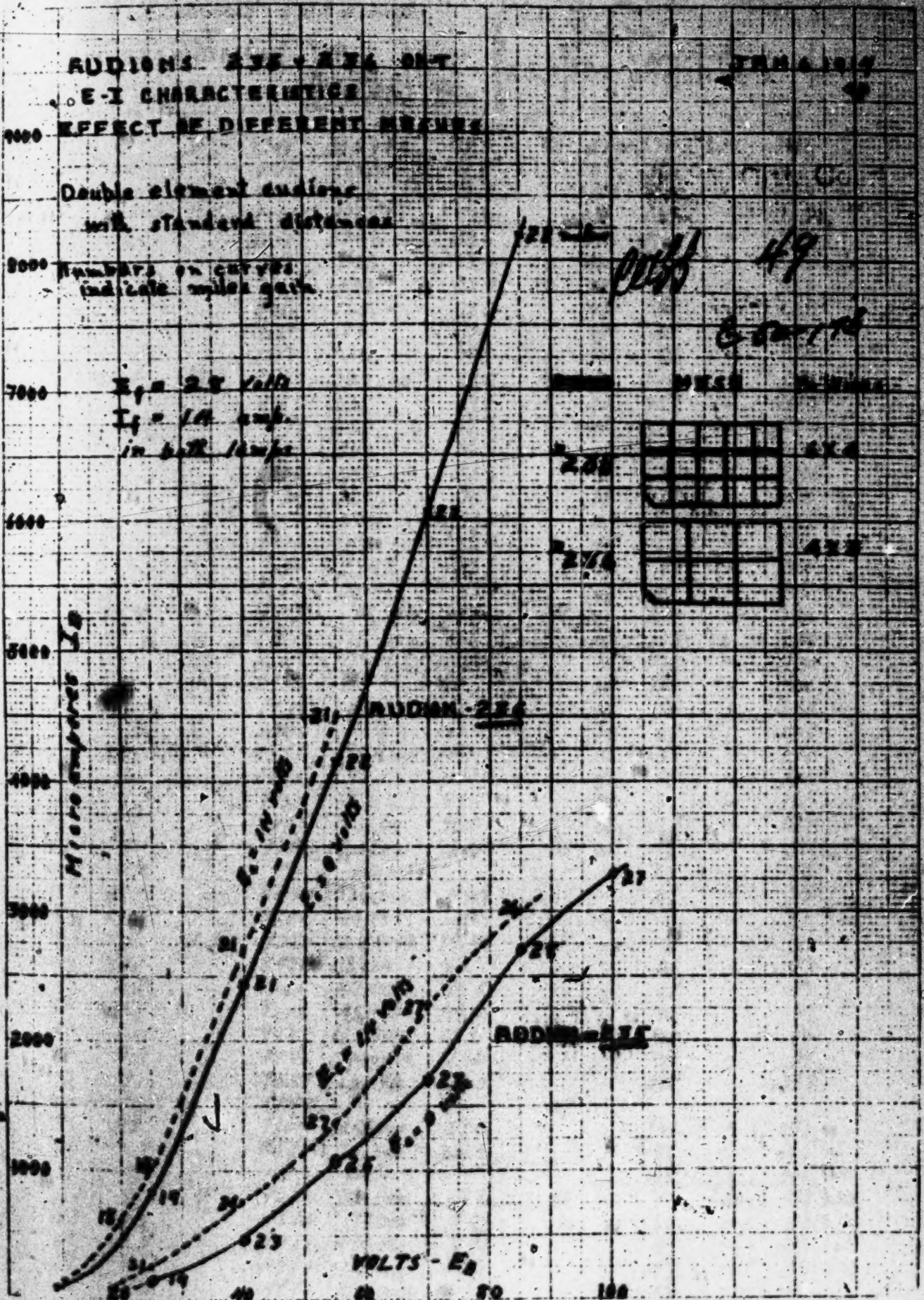
Sketch ES111730, dated January 6, 1914

811

BK 50 P. 56-57

WESTERN ELECTRIC COMPANY, NEW YORK, U. S. A.  
ENGINEERING DEPARTMENT

Sketch No. ES 111730





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**PAGE**

PLAINTIFF'S EXHIBIT No. 80

Page 72 of Notebook No. 80

Febr. 3, 1912

Audion S.S.

(Data taken Febr. 1 on broadcast by Nicodem station)

File Current = 35.5 amp

Input			Output							
A.C. Volts	A.C. Amps	Power (Watts)	A.C. Volts	A.C. Amps	Power (Watts)					
1	0	3	9200	145.000	723	40	5000	10	600	393
2			9170	111.	81.8	10	181			365
3			9170	113.	77.5	15	157			345
4			9200	116.5	72.8	20	139			302
5			9150	123.3	73.0	25	102			270
6			9250	123.3	73.0	30	88			247
7			9150	128.8	73.0	35	78			222
8			9260	135.	72.0	40	68			222
9			9250	139.	67.8	45	55			193
10			9280	139.	67.8	50	42			170
11	-1.4	3	9840	207.000	43.5	40	5	210		378
12			9580	228.	38.5	10	158			340
13			9595	237	38.0	15	131			300
14			9610	246.	36.6	20	101			270
15			9620	253.	35.6	25	86			245
16			9630	260.	34.6	30	72			223
17			9645	272.	33.1	35	64			209
18			9645	270.	33.4	40	59			198
19			9660	284.	31.7	45	48			180
20			9665	288.	32.1	50	41			162
21	+1.4	3	8815	74.300	12.1	40	5	210		378
22			8840	76.300	11.8	10	158			340
23			8880	79.4	11.3	15	131			300
24			8910	81.7	11.0	20	101			270
25			8930	83.4	10.8	25	86			245
26			8945	84.9	10.6	30	69			219
27			8951	85.4	10.4	35	57			199
28			8965	89.	10.1	40	57			190
29			9020	92.	97.8	45	37			160
30			9035	93.600	96.0	50	28			134
31	0	.5	9300	132.000	1.88	55	35			50
32	-1.4									57
33	+1.4		8420	53.900	4.69		27			58
34	+2.8		8270	47.800	5.24		8			31
35	0	1.5	9280	129.000	17.45	35	4			72
36	1.4		8430	53.600	4.2		21			53
37	2.8		8260	47.400	47.5		18			49
38	4.0		8210	45.900	49.0		15			44
39	-1.4		9940	165.500	13.6		60			77
40	-2.8		9995	2.000.000	1.12		49			77
41	0	3.	9240	131.500	74.5		57			193
42			9240			35				
43			9600	242.000	37.5		262			187
44	-2.7		9865	732.000	12.3		195			126
45	-4.						102			126
46	0	4	9220	112.000	13.6	35	74	600		228
47	-1.4		9310	174.000	8.45		63			126
48	-2.7		9760	406.000	3.85		39			164
49	-4.		9915	1162.000	15.7		37			135
50	-6.4		9990	999.000	1.6		13			46
51	+1.5		9820	73.600	21.2		60			209

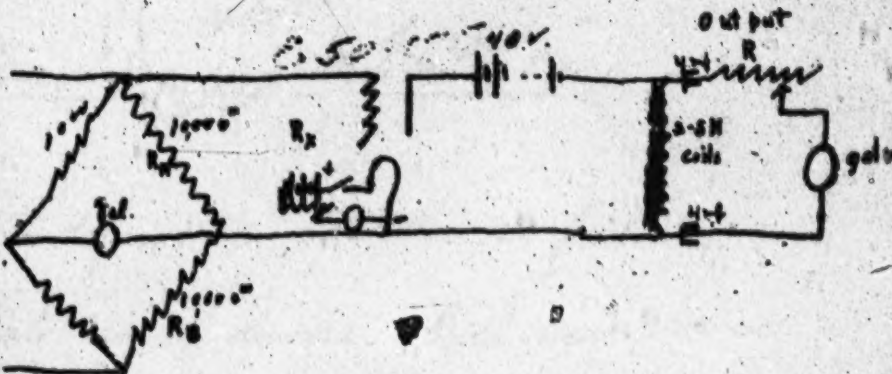


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**PAGE**

A.H. Stage across  $\beta = 8.4$   
with negative terminal of  $\beta$  at the common point

Power I R <sub>st</sub>	Gain (Power) Power in
773	9.88
1334	16.25
1680	21.2
1825	23.6
1820	24.9
1830	25.1
1885	25.8
1990	27.6
1790	25.7
1630	23.2
7730	17.8
1155	29.2
1350	33.3
1460	40.
1500	41.
1490	43.
1530	46.3
1570	47.
1555	49.1
1520	49.2
7720	63.9
1155	9.8
1350	11.9
1460	13.3
1380	12.8
1440	13.6
1380	13.3
1445	14.3
1330	12.6
1070	11.2
824	46.4
1120	0
1120	35.2
536	64.2
1220	10.4
98.0	2.33
840	1.77
676	1.36
277	20.4
216	19.5
1305	18.2
1225	32.7
1000	10.9
900	0
740	13.4
510	14.8
740	23.5
410	28.
170	37
100	196.
100	7.1



All experiments heretofore  
the A. Batt. negative terminal was  
the common point.

ES-Sketches 51313  
56719  
51315  
56316



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**PAGE**

Dr. Arnold's memorandum, dated March 15, 1914

Mr. Arnold

Miss Melick March 15, 1914

Pl. make  
The induction of a detector.

I define a detector as follows:

"A detector is a device which can be so associated with an instrument insensitive to currents of wireless frequencies as to cause it to respond to wireless signals"

In the receiving antennas of a wireless station are generated E.M.F.s oscillating at frequencies greater than 50,000 per sec. The detector is usually so associated with the antennas that across it are impressed oscillating E.M.F.s of the same frequency as occur in the antennas. Suitable variations in the amplitudes of these oscillations constitute the signal. In general signals consist of groups of



oscillations of nearly constant amplitude  
 spaced by groups of nearly zero amplitude.  
 I shall consider this class of signals only, but  
 the same remarks will apply with proper changes  
 in terminology to signals consisting of  
 variations of amplitudes, the amplitudes  
 never becoming zero. The discussion does  
not apply to the case where the detector is  
 acted upon by high frequency E.M.F. of  
 steady amplitude, the frequency being  
 varied to produce the signal.

Neglecting devices for tuning etc, there are two typical circuits in use with the audion.

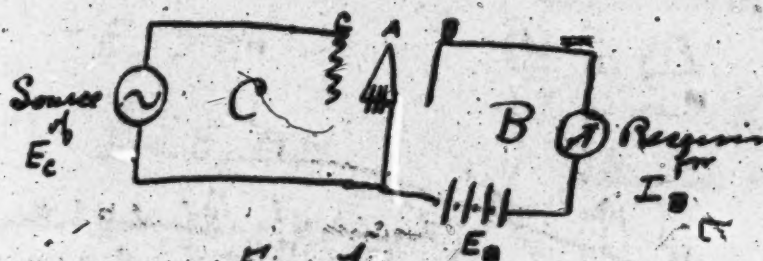


Fig. 1.

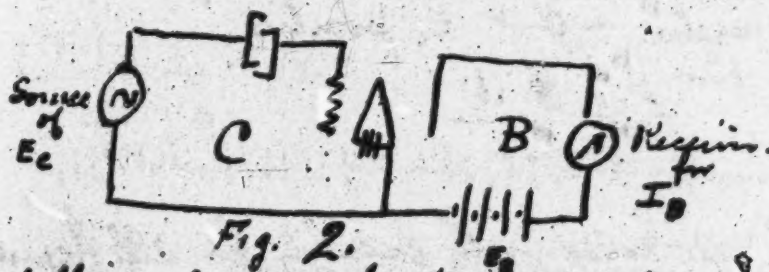


Fig. 2.

These differ only in the presence of a condenser in circuit 2.

### Discussion of Circuit 1.

The following is a typical curve of the relation between current in the B side and potential impressed on the C side.



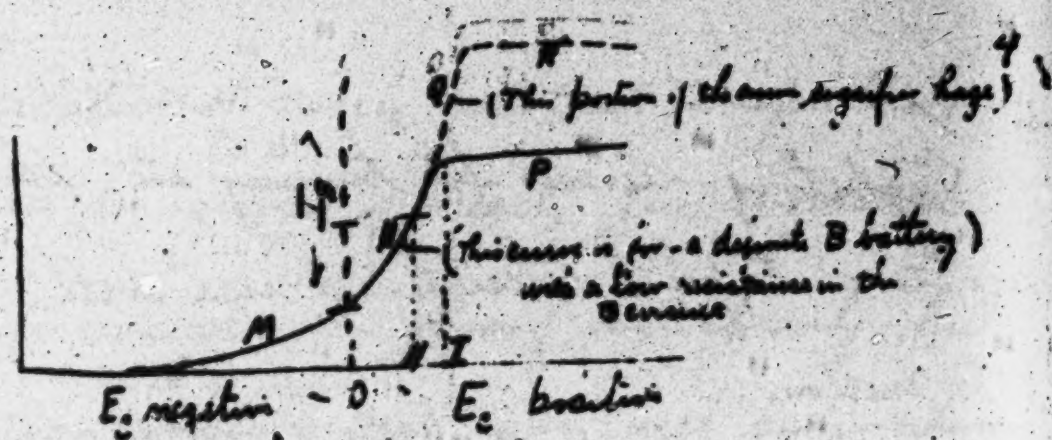


Fig 3. (a)

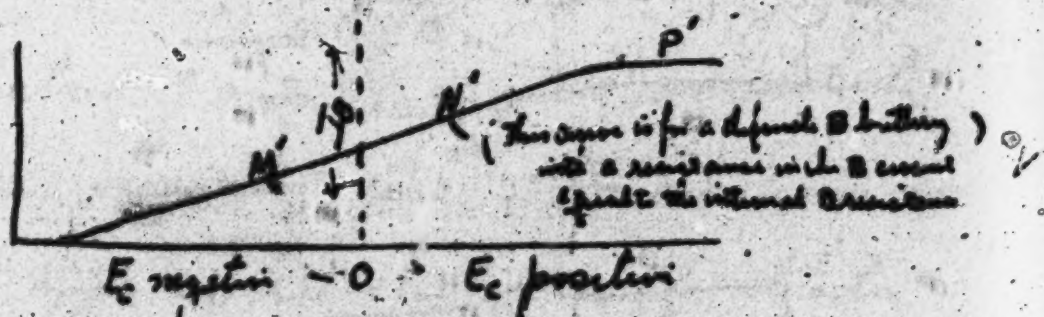


Fig 3. (b)

These curves are traced with facility for all frequencies of  $E_c$  which have been investigated, and I believe from physical facts and arguments at command that no great deviation will be found up to frequencies of the order of 12,000,000 per sec.

(Note: The lowering of curve Fig 3(a) into curve Fig 3(b) is caused by the drop in potential through the B resistance, and the corresponding decrease in P.E. between B and A, as the B voltage increases.)

Fig 3(a) shows, Relation in various conditions

2. making various detector operation.

For discussion in following conditions:

- (I)  $E_c < H$  {  $H$  is value of  $E_c$  at which  $I_0$  }  
{ means drops its normal value } }
- (II)  $E_c > H$
- (III)  $I < E_c < H$  {  $I$  is value of  $E_c$  at which }  
{ detection begins. } }
- (IV) The effect of hage

(I)  $E_c < H$ .

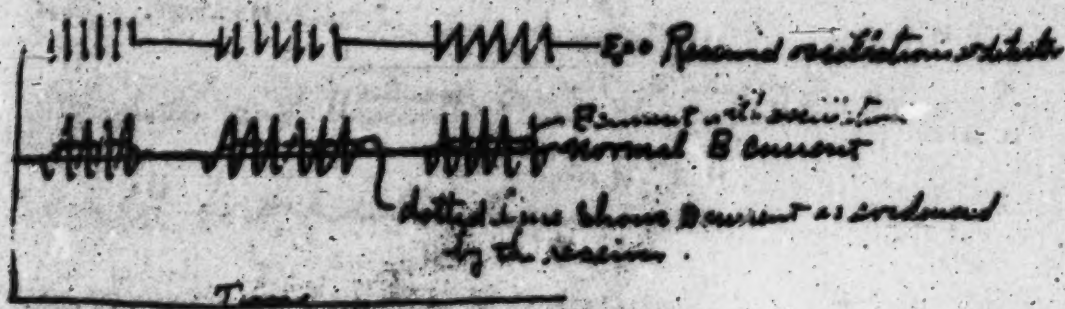


Fig. 4.

Fig 4 in connection with the above Fig 3(a), shows without further explanation the operation in this case



(II)  $E_c > H$ 

This differs from the preceding in magnitude of effect only. If  $E_c$  extends beyond the value at which saturation begins the device becomes less efficient as  $E_c$  is further increased.

(III)  $I \leq E_c < H$ 

To avoid confusion I will draw a new curve.

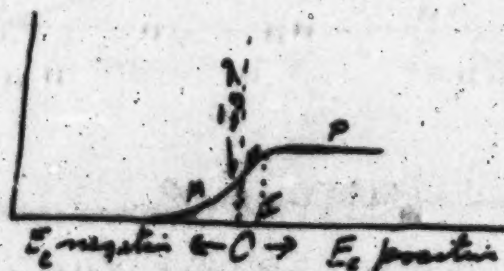


Fig 5.

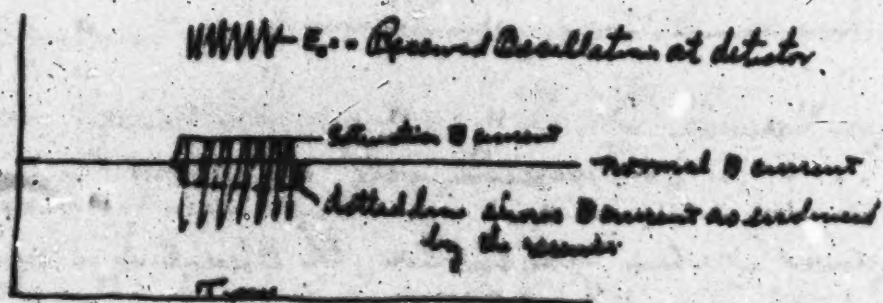


Fig 6.

The method of operation can be deduced from the curves.

(IV) The effect of haze.

If haze begins it is in effectually current  
operation as a detector, being invariant to  
current between A B and C.

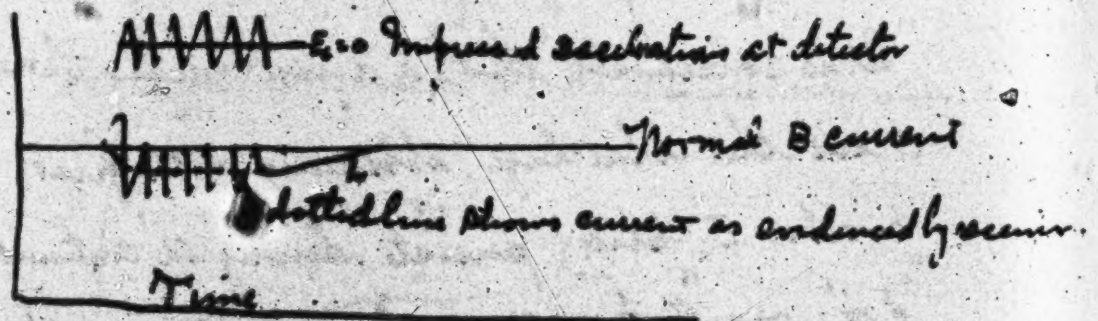
If haze occurs only at the positive peaks of  
the C wave operation proceeds as in (I)

It is conceivable that a device might be so  
made that blue haze, appearing on the first  
positive  $E_c$  peak, persists during the continuous  
of the oscillation period, lowering the resistance  
of the plate and increasing the B current. This  
would be but little different from (I) and  
need not be further considered.



## Discussion of Circuit 2.

The first positive peak of the impressed oscillations may cause the collection of electrons on C, which having no way of escape inside the bulb can only be dissipated by external leakage.



The leakage portion  $L$  will have an extension in time directly proportional to the leakage resistance. By properly proportioning the leakage this <sup>(current)</sup> may be made to return to a normal condition in time for the next group of oscillations.

In any event, even with high leakage resistance, the groups of waves will be evidenced, step by step, by decrease in the B current.

7. Conclusion:

The receiver can only indicate signal if the current then it decrease or increase for every group of oscillations.

(a) The current may increase with a group of oscillation.

Circuit 1 (I) & (II)

(b) The current may decrease with a group of oscillation

Circuit 1 (III)

Circuit 2

The last of these is the way in which the Audin operates, as usually connected for wireless telegraph receiving.

L. D. Arnold



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**PAGE**

Pierce's memorandum, dated March 10, 1914

Mr Arnold,

This report is merely a compilation of data obtained with different grids. It is written up to let those interested know just what work has been done.

P.H.P.



March 19, 1913

## Experimental Audions

Grid Distance *Wk* 53

650-175

In a report of Oct. 16, 1913 an experiment was described in which an audion having different grid distances on either side of the filament was tested. The grid which was the closer to the filament showed the better results. See ~~ES~~ Sketch No. ES. 93579. In a later audion the grid distance on Side A was made  $\frac{3}{2}$ " and the plate distance  $\frac{1}{2}$ "; and on Side B, the grid distance  $\frac{3}{2}$ " and the plate distance  $\frac{1}{2}$ ", the grids being the same distance away from their respective plates. The results from this lamp are recorded on ES. 111740. Side A having the closer plate and grid distance gave much the larger space currents and gains for any given plate voltage and also greater gains for equal space currents and different plate voltages.

## Grid Opening

A series of tubes was made to determine the best size of mesh to be used at a given grid distance. Fourteen audions were constructed in seven pairs. They were evacuated on pairs or on T's for the sake of comparison and elimination of the question of vacuum. They were all double element audions some of which had different grids on the two sides of the filament.

In all the tubes the bulbs were  $2\frac{1}{4}$ " diameter, the plates  $\frac{1}{2}$ " apart and the grids  $\frac{7}{32}$ " apart. The plate size was  $1\frac{1}{2} \times \frac{5}{8}$ ". The filaments were platinum twist coated with barium resinate.

The first series of experiments on these audions was the determination of the gain and  $E_b$ - $I_b$  characteristics in a one-way standard audion circuit in which the high side of the input transformer was designed to work into  $30,000\Omega$  and the high side of the output transformer into  $35,000\Omega$ . As the input and output resistance of the audions with different meshes varied considerably the comparison of efficiency of the different meshes on the tuning circuit is only approximate. The numbers on the  $E$ - $I$  curves indicate the miles gain obtained at the particular values of  $E_b$  and  $I_b$ .

Sketch E.S. III 739 shows the curves obtained from data using meshes shown on the sketch. The large mesh gave the greater space current and greater gain. Sketch E.S. III 729 shows the results for six audions having special meshes on one side of the filament and standard grids on the other side. These curves show that the larger meshes allow greater space currents and greater gains. These curves were obtained with a grid voltage of  $+1.4$  volts. The characteristics with  $E_c = 0$  are shown in E.S. III 732 and show more clearly that the 7x5 wire and 6x4 wire mesh are better than the 10x0 and 8x5 wire mesh.



The difference in the 7x5 wire and 6x4 wire meshes were not apparent from these curves, therefore two audions were made on a T having on one a double element 7x5 wire mesh and on the other 6x4 wire mesh. The results of this pair of tubes are shown in Sketch ES. 111735. The space current ( $I_0$ ) for the larger mesh is the greater but the gains are practically the same. When we consider that the output resistance of the tube with the 6x4 mesh is 21,000 $\Omega$  and that the tube with the 7x5 mesh is 33,000 $\Omega$  which is the proper resistance for the output transformer used, it may be that the 6x4 mesh is the more efficient. Sketch ES-111735 shows the  $E_c - I_0$  and  $E_c - I_c$  characteristics for these two tubes.

Two more pairs of tubes were constructed one tube of each pair having 6x4 meshes and the other tube of each pair having 4x3 wire meshes. The resulting curves from these tubes are shown on Sketch ES. 111736 and 111737. It is quite apparent that the smaller mesh (6x4) is the better.

A second series of experiments were made on most of the audions previously described, in which the absolute efficiency was measured in a bridge circuit such as shown in Sketch ES. 111938. The input and output impedances of the audions to 1000 AC. were measured in a carefully shielded bridge. The input AC. voltage was maintained constant and the output current thru a resistance equal to the output impedance



measured on a Duddell Thermal galvanometer in order to measure the input impedances with any degree of accuracy a positive C battery of 1.4 volts was used. The same or greater efficiency could be obtained with a C battery of negative 2.5 volts by boosting the B battery voltage to obtain the same space current as with positive C battery.

ES-115522-A, E.S. 115523, and ES 93939 show curves for input impedance, efficiency, and output impedance for varying B battery voltage, for audions with several different meshes. The results bear out the conclusions reached from the talking circuit tests and indicate that the 6X4 mesh is more efficient than the 4X3 and 7X5 meshes.

At the request of Mr. Van der Bijl three audions were made on a T alike in construction having 7X5 meshes of different diameter wire. They were tested on the talking circuit and on the bridge circuit. The results are recorded on Sketch ES 115523 and on ES 93940. Both tests indicate that the .008" wire is a better size of wire to adopt than .015" or .006" on the particular construction used.

Sketch B shows the efficiency of an audion of standard B construction, that is having an 8X2 mesh.

Sketch C shows the efficiency of several audions especially designed to handle large energy.

O. H. Pierce



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**PAGE**

Dr. Arnold's memorandum to Mr. Colpitts,  
dated April 17, 1914

Audion Amplifiers without Transformers

MR. E. H. COLPITTS:

April 17, 1914.

This relates to the use of audions as amplifiers in circuits from which it is advisable to exclude transformers.

Among such circuits may be noted:

1. Those in which the frequency is so low that efficient transformers are costly and difficult to design. (This includes telegraph circuits; land, submarine and wireless).
2. Those in which an exact reproduction of wave form is necessary for legibility (e.g. cable telegraph circuits).
3. Those in which undistorted amplification must be secured over a wide range of frequencies (e.g. in the reproduction of speech and music), in which cases the inherent selectivity of a transformer is undesirable.

With the audion at present on the market, transformers must be used to secure appreciable amplification. This is especially true when amplification is desired in circuits of low impedance.

The explanation for this is found in the characteristics of the audion itself. The impedance of the input side of an audion operating efficiently is greater than 100,000 ohms and it does not appear that any practical structural change can



much reduce this. Hence, if it is desired to secure amplification in a circuit of, say, 1000 ohms impedance, at least 90% of the possible current amplification must be lost if no transformer is used.

Moreover, with the present commercial audion structure the impedance of the output side is always so great that a considerable loss of possible amplification must occur if we attempt to operate without transformers into a line of impedance of the order of 1000 ohms.

It has been found possible to construct audions with any desired output impedance, but no modification of this kind has produced a single-audion structure which will operate to advantage in low impedance circuits from which transformers are excluded.

Obviously an attempt might be made to use several audions, the one operating into the next, etc., in the hope that by such a succession of devices the output and input losses noted above might be so far overcome as to render the complete operation of value.

Various attempts at so-called "cascade" operation have been made by DeForest and others, but never, so far as I am informed, in circuits from which transformers are excluded.

In the course of our experiments we have discovered that certain forms of audion structure are especially adapted to this end.

In particular we have been able to make audions which, without the use of transformers, provide the possibility of stepping up the input voltage, (either D.C., or any frequency

A.C.) in one step to as much as 30 times its original value, or, in two successive steps to as much as 500 times its original value. The voltage amplification thus secured is entirely free from distortion whatever the initial frequency or wave form.

We have also succeeded in making audions which step down the input voltage to one-third its original value. It is not because of this property that this latter type is of value, however, but rather because its output impedance can be made as low as 500 ohms, and hence it can be worked efficiently into a line of like impedance.

These two types\* of audions I shall call for convenience the "A" and "B" types, it being remembered that the "A" type effects a step-up transformation of voltage, while the "B" type is suitable for direct connection to a low impedance output line.

We have found that a combination of two of the "A" type in cascade working into one of the "B" type will operate from a line of 250 ohms impedance into a like line, with a resultant current of more than 50 times that which would flow in the second circuit if it were direct connected to the first circuit.

The importance of this for submarine cable circuits, can hardly be over-emphasized, and the control of this apparatus for this purpose in countries where cables terminate, should place the owners in a unique position.

It must be admitted that the "B" type audion is not an essential to this scheme of operation. We may replace one of the "B" type by from 10 to 100 of the "A" type in parallel, and secure comparable results. It is obvious, however, that the use of one audion of the "B" type is to be preferred. It is, \*A brief description of the A and B types will be found on the enclosed sheet and Figure 1



however, necessary that audions of the "A" type be used at the input end, since only this type has the property of voltage step-up transformation.

An essential part of the system of amplification is the circuit whereby the several elements are interconnected without the use of transformers. The figures will make clear the methods which we have used.

As a structural feature it should be noted that it is possible to combine in one bulb, and with a common filament, the "A" type and the "B" type audion, so that the resulting bulb allows of direct operation, with amplification, between lines of low impedance without transformers.

With reference to the use of this scheme for the amplification of telephonic currents, we have found that remarkably perfect reproduction can be obtained, and while if but a single amplification is needed transformers are successfully employed, if there is a call for successive amplifications, and especially if a loud speaking receiver is at the terminal of the line, improved results are obtained with the present scheme.

There is an additional interesting feature which should be mentioned. The input impedance of the audions as we are using them exceeds 10,000,000 ohms. It is obvious that inserting one of these in shunt across a line produces no effect on its apparent impedance. Indeed one can draw from a line of 1000 ohm impedance sufficient energy to operate a very large number of such audions in parallel without appreciably affecting the impedance of the line. This desirable result can hardly be

accomplished where transformers are used operating from the line into the audion.

A similar condition exists at any point where we are passing without transformers from one audion to the next. As many audions (possibly not exceeding 100) as desired may be multiplied off from any one, without in any way affecting the operation of the others.

As to the uses of this system other than to operate at higher speeds siphon recorders on cable lines, and for circuits where especially pure reproduction of speech or music is desired, I might mention the possibility of replacing the siphon recorder by a cheaper and more robust instrument; the possibility of direct repetition from cable to land telegraph lines; the possibility of the operation of various selecting, printing and recording devices, etc., etc.

The device is at present in operating condition to give a current amplification of 55 times between circuits of 250 ohms impedance, with sufficient energy capacity to deliver at least one-tenth of an ampere at its terminals. An entirely simple modification will allow the amplification to be enormously increased, and while we have not yet constructed a device capable of delivering more than a quarter of an ampere through 500 ohms, to do so is only a mechanical matter. We are sure that a current of one ampere could be handled without difficulty, and are hoping that even larger outputs can be provided for.

The appended figures, together with their descriptions, show circuit arrangements which we have found useful, of which



Figure 2 shows a plurality of "A" type in cascade working into a plurality of "A" type in multiple, the output going to a common circuit.

Figure 3 shows the same result secured in a simplified circuit.

Figure 4 shows a plurality of "A" type in cascade working into one of the "B" type

Figure 5 shows the same result secured in a simplified circuit.

Figure 6 shows a further circuit modification of the set of the previous figure.

Figure 7 shows a plurality of "A" type in cascade working into a plurality of "B" type in multiple; each of the "B" type feeding into a separate output circuit.

Figure 8 shows a circuit arrangement for an "A" and a "B" type combined in one bulb, with a common filament.

#### CONCLUSION

From the scientific and the engineering points of view we have made important progress in the following several respects:

1. We have discovered the fundamental factors and their relative importance in audion structure to such an extent that we are able to make one particular type of structure which provides a large amplification of input voltage, and another type of structure which provides large amplification of current with considerable diminution of voltage.

2. We have designed circuit arrangements such that a combination of audions can operate without the use of transformers, and even between circuits of low impedance, can give an output current in excess of 50 times the arriving current for all frequencies from those suitable to wireless signaling down to the lowest frequencies used in cable telegraphy.

We consider that this advance in the art is of momentous importance certainly in the field of cable telegraphy and probably in the allied fields of land telegraphy, and wireless telegraphy, especially with reference to recording, high speed working, and direct repetition from one type of system to any of the others.

If there is held to be anything novel in the system we believe especial care should be taken to protect its use in those countries where long distance signals are likely to terminate, be repeated, or be transferred from one of the systems (cable, land, wireless) to another.

As for telephone and allied uses, we have found in our brief experience with it some marked advantages, especially in the loud reproduction of speech and of music.

H. D. ARMOLD  
EI

Enc.





**FIGURE 1****A AND B STRUCTURES**

In type A the grid, preferably appearing on both sides of the filament, is made of very fine mesh of very fine wire, and the plate is placed at a considerable distance from the filament. The filament need not present a large active area. The three things fundamental to successful voltage transformation are:

1. Grid must be near filament.
2. Plate must be distant from filament.
3. Grid must present a finely meshed surface between filament and plate.

In type B the grid, which may be a single wire, may be on any side of the filament, but preferably makes with the filament a plane parallel to the plate. The plate is placed as near to the filament as is conveniently possible. The filament is preferably in the form of several linear strips, each with its appropriate grid wire, and must present a large active area. The four things essential to successful amplification in a circuit of low impedance are:

1. Grid must be near filament.
2. Plate must be near filament.
3. Grid must present the least possible obstruction between filament and plate.
4. Filament area must be large.

**FIGURE 2**

In this circuit two A type in tandem are shown working into three A type in parallel. The batteries  $V_3$  are adjusted to the proper values to make each grid about five volts negative with respect to its adjacent filament.

The filaments are heated by means of the batteries  $V_1$ , and the plate circuits are supplied with current from the batteries  $V_2$ .

The input voltage on the first grid causes a change in the current flowing to the plate through the high resistance  $R$ . This develops a voltage change on the grid next in series, and so on. For successful operation the resistances  $R$  should be of the order of 100,000 ohms or more.

The three final audions are shown working into a common output line. This presents to the output line an impedance equal to the value  $R$  divided by the number of multiplied audions. Hence for the most successful operation into a line of 500 ohms impedance we would require a large number of audions in parallel.

**FIGURE 3**

This circuit effects the same result as the circuit of Figure 2, but in a simplified manner. A common filament battery, and a common plate battery serves for all the audions. The batteries  $V_4$  are introduced to compensate for the voltage drop through the filament.

**FIGURE 4**

In this circuit two A type audions in tandem are shown working into a B type audion. The operation is in all



other respects similar to that of Figure 3. It presents as an advantage over the circuit of Figure 2 the use of one audion properly designed in place of the large number of ordinary audions used in Figure 2.

#### FIGURE 5

This shows the same results obtained in the circuit of Figure 4, except that the audions are operated from common filament and plate batteries.

#### FIGURE 6

This shows a further simplification of the preceding circuits in that the various  $V_3$  batteries may be largely reduced in voltage. This circuit is particularly applicable to telephone rather than to telegraph working.

#### FIGURE 7

This shows two A type audions in tandem working into a number of B type audions. It differs from the previous figures in that each B type audion is shown working into its own output circuit. This is particularly applicable to the operation of several telephone circuits or loud speaking receivers from a common talking circuit.

#### FIGURE 8

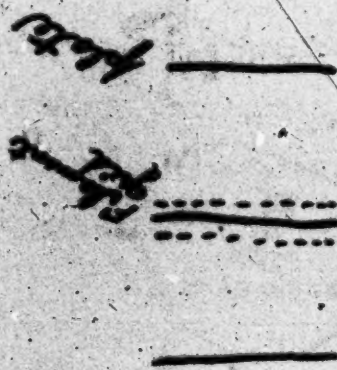
This shows a structure and circuit in which one bulb contains the entire necessary audion structure. The bulb contains an A type structure and a B type structure, operating from a common filament. The structure has been found to operate successfully between lines of the impedance of ordinary telephone lines without the interposition of transformers.

ES 160004



Type B

Use a purple wire or  
very coarse mesh  
Plate near filament



Type A:

Use a fine mesh of fine wire  
Plate distant from filament

Fig 1 (To accompany memo 3022- E.M. 4/14)  
I 987



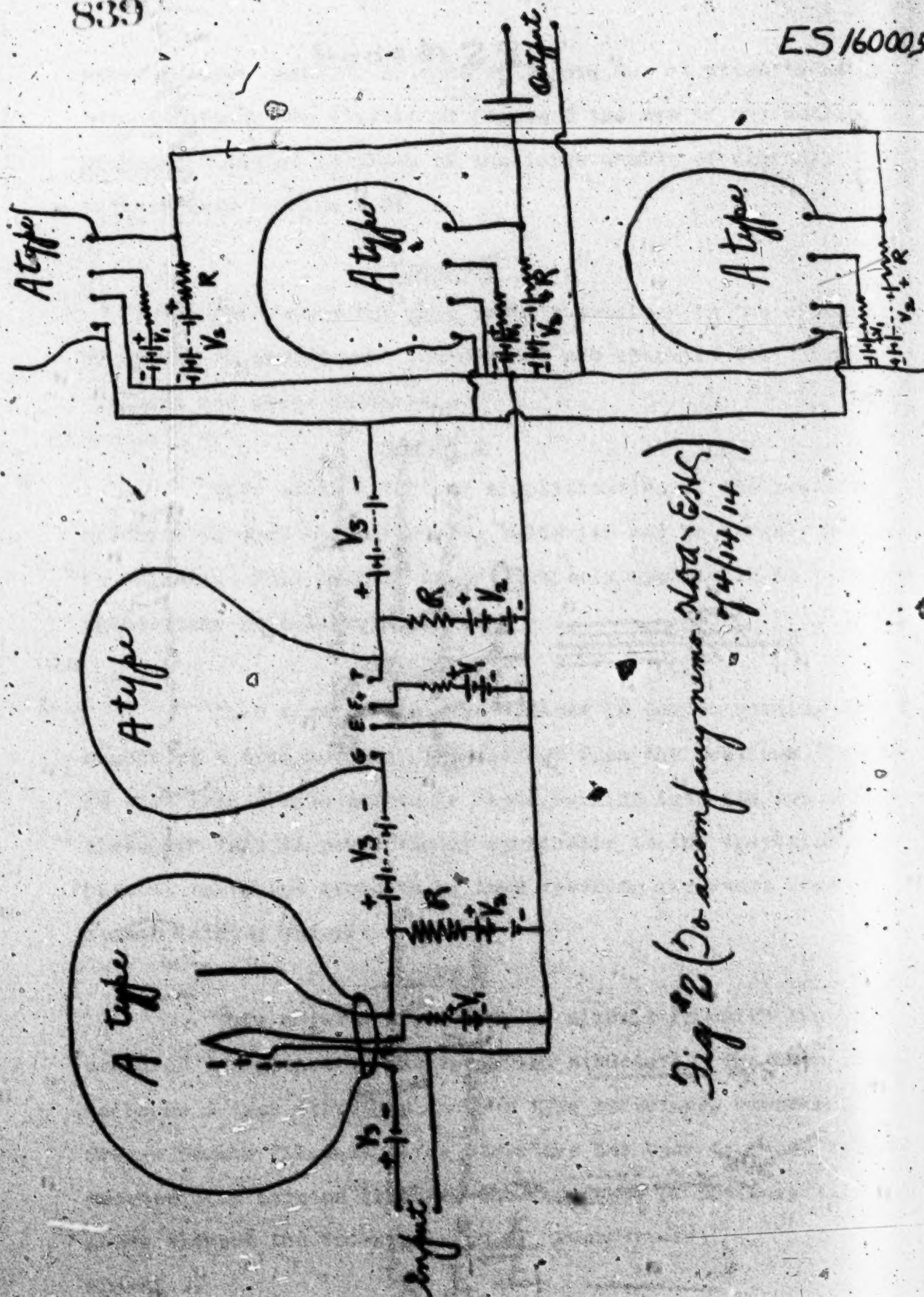


Fig. 2 (To accompany memo No. 2-ENR)  
of 4/14/14

ES 160006

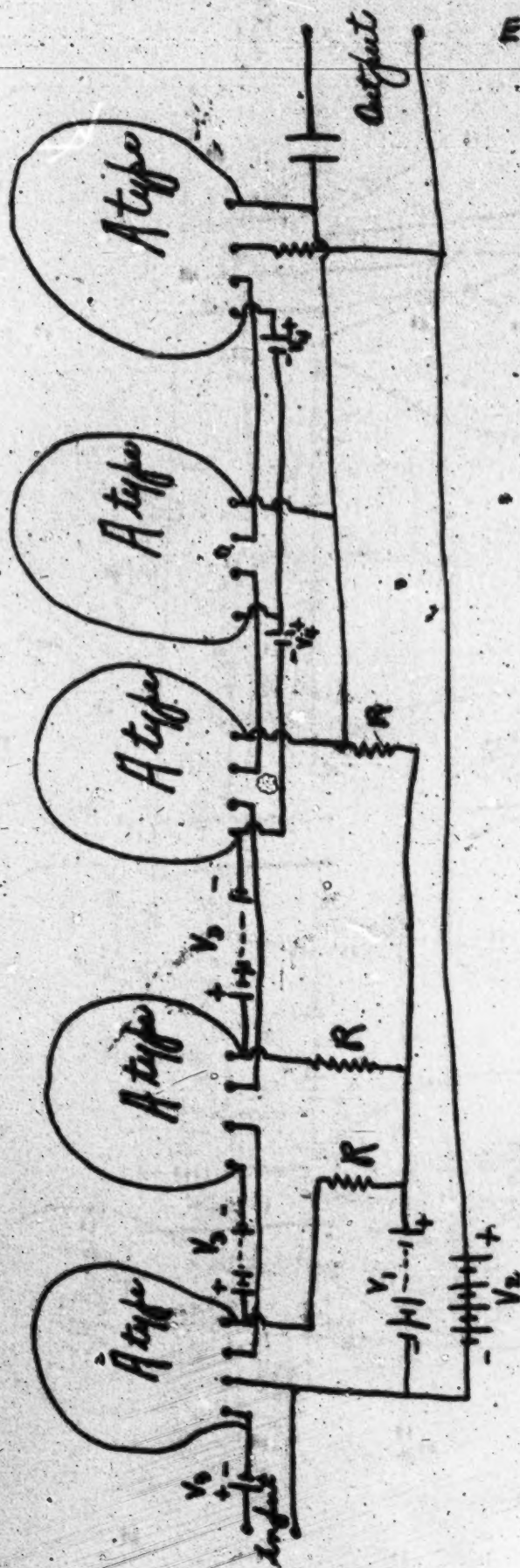


Fig #3 (To accompany memo No 2 - ESR of 4/14/44)



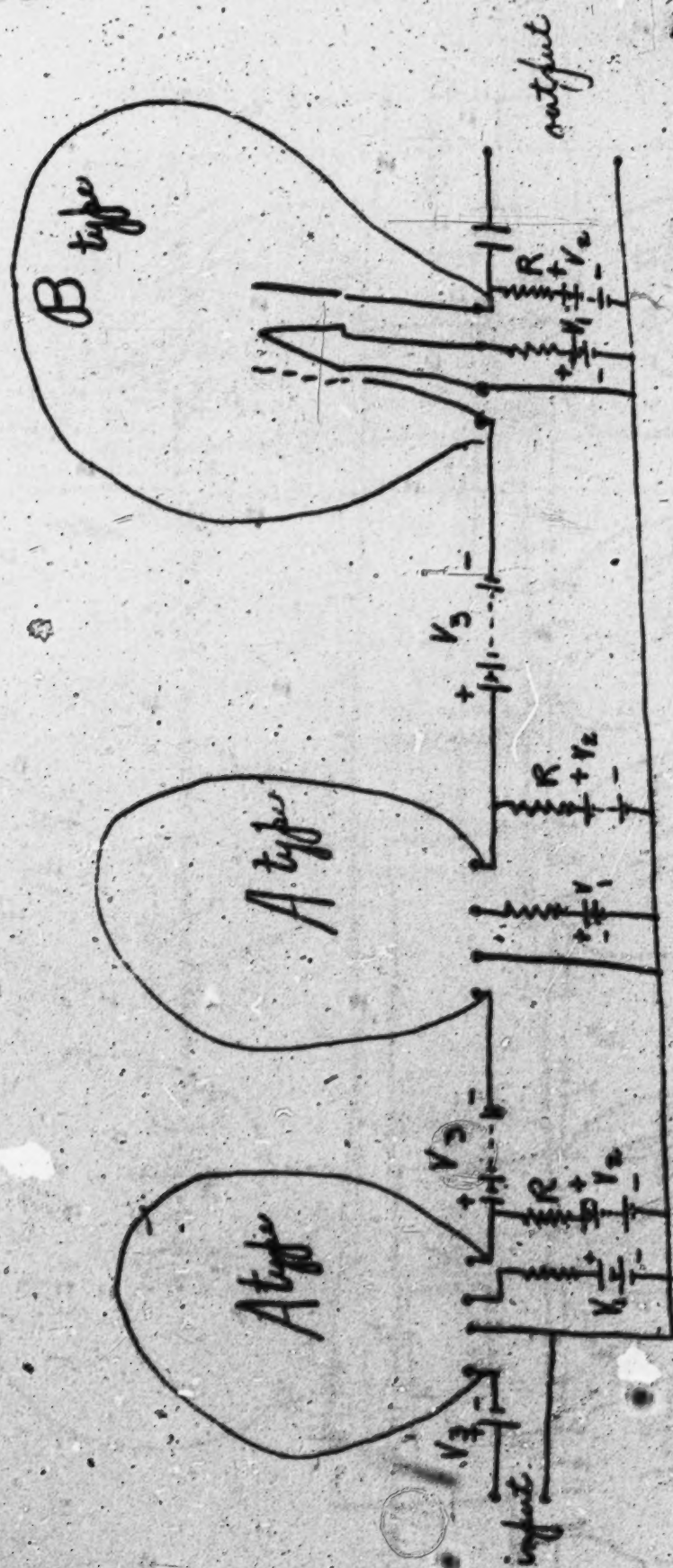


Fig 4 (to accompany memo 2402- E&S of 4/14/44)

ES 160008

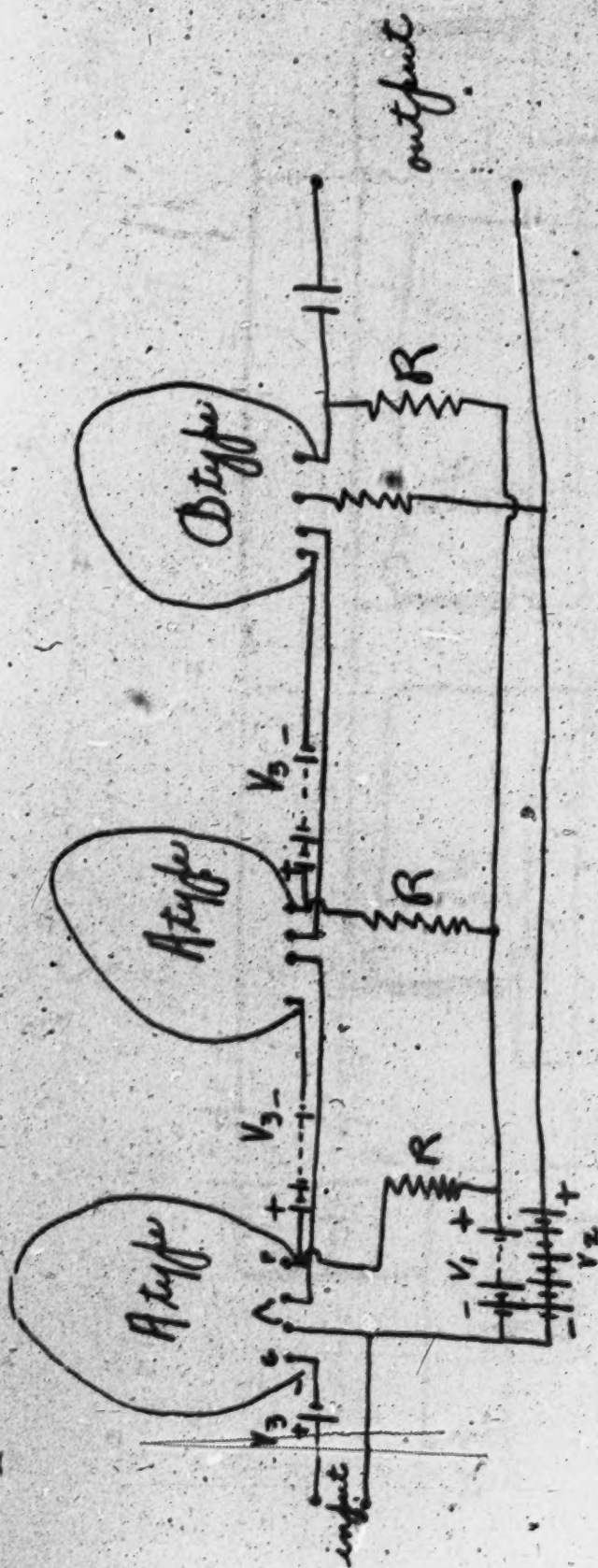


Fig #5 (To accompany memo No. 160008 of 4/14/44)



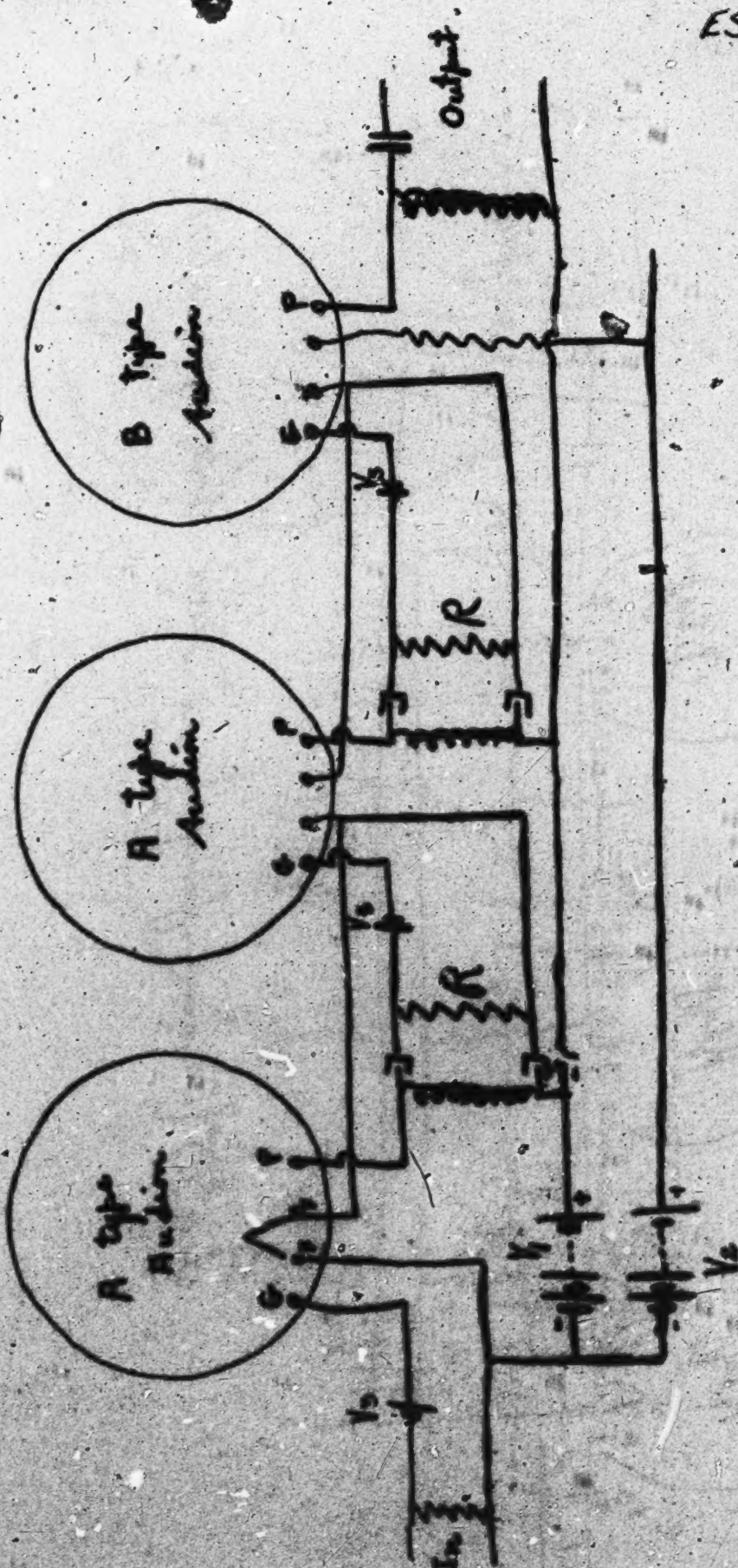


Fig 6 (To accompany memo 3602-605 4/14/14)

ES 160010

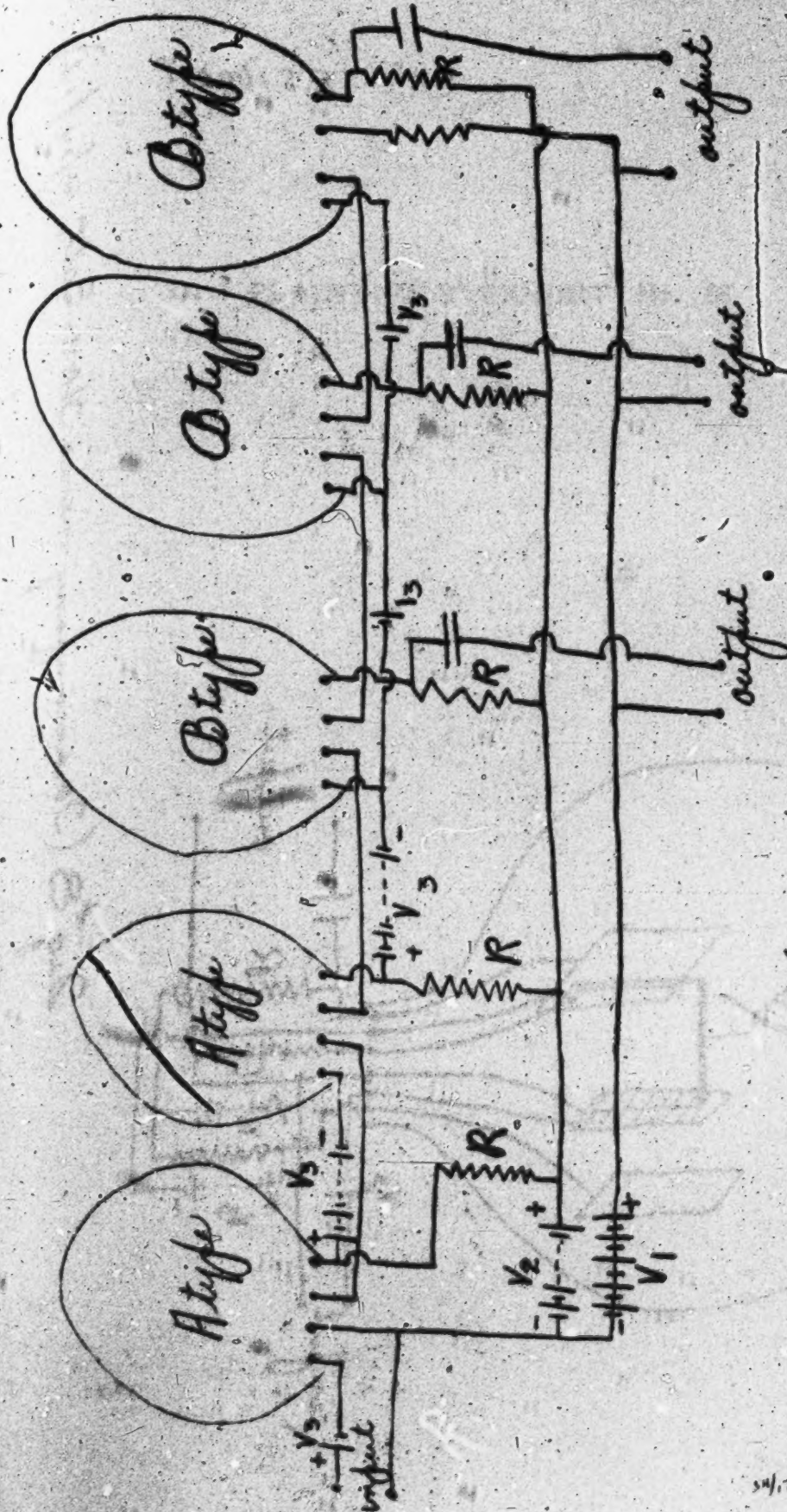


Fig. #7 (To accompany memo No. A-ES 5 of 4/14/44)



9

ES/60011

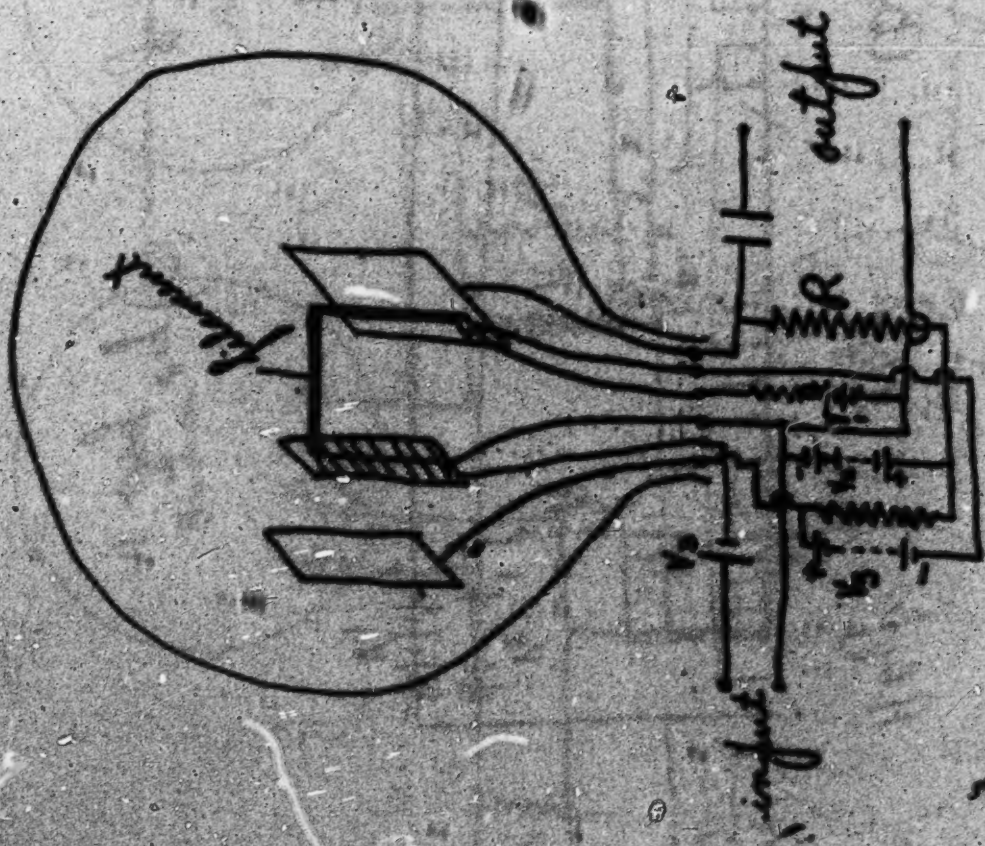


Fig. 8 (Vacuum tube memo Nov. 1945)

**PLAINTIFF'S EXHIBIT No. 55**



May 9, 1933.

R. T. CLOUD

1,907,741

ELECTRIC AMPLIFIER

Filed June 9, 1930

Fig. 1.

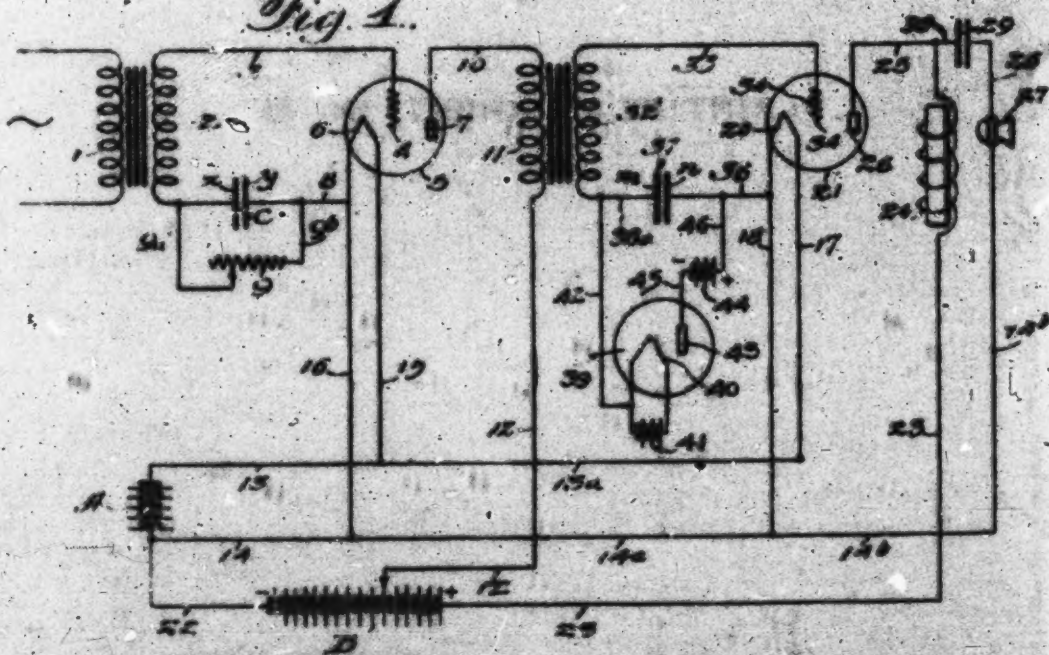
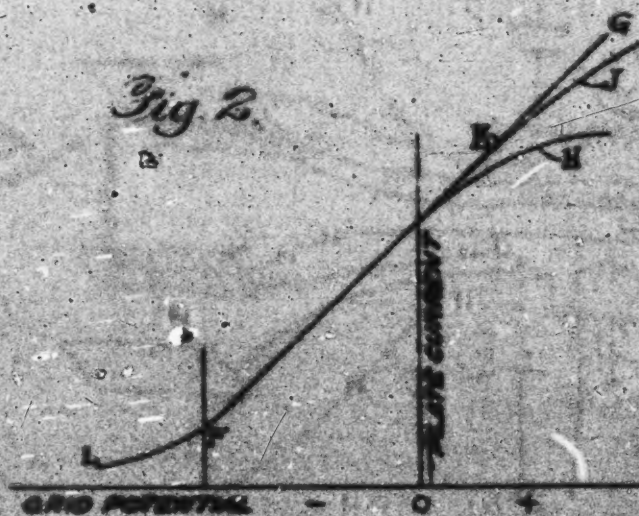


Fig. 2.



Inventor  
 Raymond T. Cloud  
 By *Lucas Johnson*  
*att*

Patented May 9, 1933

1,907,741

## UNITED STATES PATENT OFFICE

RAYMOND T. CLOUD, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-HALF TO EUGENE H. ZELONY, OF NEW YORK, N. Y.

## ELECTRIC AMPLIFIER

Application filed June 2, 1929. Serial No. 489,392.

This invention relates to systems for amplifying electric currents.

The chief object is to provide an audio-frequency amplifier of high efficiency. This includes freedom from substantial distortion and the requisite volume in the sound output. More specific objects are simplicity, the use of relatively low battery or other power voltages, a greater range of signal voltage excursions, including substantially wide excursions into the positive field, with means for shifting the operating point of the signal excursions to keep the range of these excursions within the substantially non-distortive field, together with all advantages as will more fully hereinafter appear or as will be readily appreciated by those skilled in the art.

In the drawing Figure 1 represents, in the usual diagrammatic way, two stages of amplification each of which is according to the present invention. The circuit for the first stage shown will be used preferably in the earlier stages while that of the second stage illustrated will be preferred for the last stage or the later stages in amplifiers having say three stages or more; and

Fig. 2 is a chart or graph representing voltage and current characteristics of a three-element amplifying tube.

The wiring diagram of Fig. 1 shows an audio-frequency transformer input primary 1 having an alternating signal current impressed thereon. One pole of its secondary 2 is connected by conductor 3 to the grid or control element 4 of the thermionic device or triode 5 which contains also the filament or electron-emitting cathode 6 and the plate or output terminal 7. The other pole of secondary 2 is electrically connected to filament 6 by means including the grid return conductor 8 in series with an electrostatic condenser C having plates a and b, this condenser being bridged or shunted by a resistor 9 and its connections 10 and 11.

The plate 7 is connected by conductor 10 to the output transformer primary 11 which is connected by conductor 12 to battery B at a point providing the desired voltage for the plate.

Battery A is connected by conductors 13 and 14 to the leads 15 and 16 respectively connected to filament 6, and the same battery conductors at 13a and 14a are shown as leading to conductors 17 and 18 respectively connected with filament 20 in the second stage tube or triode 21.

Battery B is connected at one end through conductor 22 to battery A or conductor 14, and at its other end through conductor 23 to choke coil 24 in communication through the conductor 25 to plate 26 of the second stage tube. Conductor 14b is connected to conductor 14a and leads to one terminal of loud speaker 27 while conductor 28, condenser 29 and conductor 30 connect the other pole of the loud speaker with plate conductor 25.

The second-stage input transformer secondary 32 has one pole connected through conductor 33 to grid 34 of second-stage tube 21. A condenser 37 having plates m and n is in the grid return including conductor 36, and shunting this condenser 37 is a two-element valve device consisting of the filament 40 heated by battery 41 and connected through conductor 42 to the conductor marked 36a on one side of the condenser 37, being the side having plate m, this valve device comprising also a plate 43, the battery 44 having its negative side connected through conductor 45 to the plate 43 and having its positive side connected through conductor 46 to that part of the grid return marked 36 and being on the side of the condenser 37 having plate n.

It will be appreciated that instead of batteries a power unit may be employed to supply current for the filaments, etc. according to what is well-known in that respect.

I may point out, also, that the present invention discloses features novel in themselves in the input circuits only, so that those circuits are the only ones calling for particular description.

The theoretical characteristic curve of the well-known triode, with respect to grid potential versus plate current, contains a substantially large part which is on a substan-



tially straight line on both sides of a point indicating zero grid potential. This line is marked F—G in Fig. 2. However, when the resistance of the ordinary audio-frequency transformer secondary is introduced into the input circuit, as at the place occupied by 9 or 32, the drop of potential through that secondary causes the curve on the positive side of the chart to deviate quite markedly from the substantially straight-line form, and is sufficiently illustrated by the line marked H. This deviation is proportionate to the ohmic resistance of such secondary, and on all but substantially small positive swings of the signal voltage the deviation is to such extent that pronounced distortion results.

In all practice heretofore, so far as I know, secondaries of high ohmic resistance have been used in the input circuits of such amplifying systems, usually with means for maintaining a negative bias on the grid to prevent the voltage excursions from entering the positive side of the curve, or if so to any extent, then but slightly.

One feature of the present invention is in the provision of a transformer secondary, as 9 or 32, of low ohmic resistance, while having the necessary high alternating-current impedance for a suitable input to such a thermionic device as a three-element tube. Owing to the relatively small potential drop through this low-ohmic secondary the excursions of the signal voltage may extend deeply into the positive side of the chart without appreciable distortion effects. The line J of Fig. 2 fairly indicates the distortion curve with a secondary of low ohmic resistance. I am thus able to utilize a much wider range of non-distortional excursions, as from F to K, than has hitherto, so far as I am aware, been found practicable.

The use of such a low resistance secondary would not alone, however, produce the desired result, primarily because an extreme excursion into the positive field the current flow on the grid circuit becomes so considerable that even the low ohmic resistance of the input secondary thus far found practicable in transformer constructions for such use would not be sufficient to maintain the operations on that substantially straight line of the graph, as from F to K, necessary for non-distortional effects.

I therefore provide means, namely a condenser C, for limiting the positive excursions to such range thereof, as to the point K, as shown a substantially straight-line graph on the positive side of the chart.

The grid or control element as 4, when positive, attracts electrons from the cathode as 1. Three negative ions accumulate on plate 2 of condenser C, building up thereon a negative potential which causes

the entire sine wave of the signal to shift downward, so that the operating point of the grid potential has moved to a lower position in the negative area according to the chart. The wave is not truncated or otherwise deformed at the top, but its base is bodily shifted to another operating position. As the flow of electrons to plate 2 is proportional to the positive potential of the grid, the operating point representing the base of the sine wave of the signal is thus automatically shifted in the negative direction. This provision, then, limits the extremity of the upward or positive swing of the signal voltage.

In connection with limiting the extremities of the excursions another consideration arises. The downward shifting of the operating point might be so excessive under such conditions as where the point of operations is well downward on the negative side as to cause distortion at the lower or negative end portion of the curve, namely at the line F—L. I therefore provide means for limiting the extremity of the excursions downward in order to prevent this type of distortion. These means are shown in the first stage of amplification as a leakage path marked 3, 3a, 3b around the condenser, the element 3 being of substantially high ohmic resistance and being preferably adjustable in order readily to provide the best operating points according to the particular requirements. It will have a resistance value depending upon the amplitude of the signals, and may vary from say a million ohms to as low as say twenty-five thousand ohms. With a variable resistance constituting this leak it is a simple and easy matter to make the adjustment as required, since the function of this leak is to prevent the "blocking" of the tube on the deeply negative excursions. If blocking occurs the resistance at 3 will be decreased.

The ohmic resistance of the transformer secondary as 9 or 32 will preferably be the lowest compatible with such factors as size and weight of the transformer complete and the inherent difficulties in transformer construction with regard to distributed capacity, etc. I find a resistance of two hundred fifty ohms for such secondaries satisfactory and practical. In various embodiments this resistance will probably vary from say two hundred to five hundred ohms. Hitherto the secondaries of transformers for interstage coupling in audio-frequency transformers have ranged from about five thousand ohms to about ten thousand ohms. In this respect the invention therefore departs quite notably from prior practice.

In this connection I may point out that transformers having such low-resistance secondaries and suitable for audio-frequency amplifying circuits are not available in the

general market, and that it would be impossible to obtain the desired results, according to these improvements, with the high secondary resistances indicated as being in common use. I may suggest, too, the advisability of forming these low-resistance transformers of the open net-work type, for example of the kind known as "pancake," with a view to the thereby reduced effects of distributed capacity.

As to the condensers marked C and 37, their capacity is not critical, so far as operation is concerned, although the value of this capacity has an effect upon the quality of the reproduction with respect to the proper balance between high and low frequencies. No specific value can be given for this capacity without knowledge of the frequency characteristics of the transformer used in a given embodiment, but in any event the selection of the most advantageous capacity value is merely a matter of ordinary engineering, once the principle is given. I have successfully employed condensers in these locations of from one-fourth of a microfarad to four microfarads.

With this further understanding of the system, it may be pointed out with respect to the condenser as C that since the electrons accumulating on plate *a* counteract the tendency of the positive excursions to extend too far, the device is self-adjusting to a suitable operating point for the grid potential; and such adjustment takes place only when the same is needed, and to the necessary extent. This counteracting influence by the accumulated electrons occurs only on the positive swing, and it occurs automatically. Its effect is to move the point of operation or base of the signal sine wave farther into the negative field, and this occurs concurrently with a swing of the grid potential into the positive field. A signal of high amplitude may tend to throw the grid potential quite deeply into the positive field, but the excursion thereinto may go only a limited distance, although to a considerably greater distance than has heretofore been found feasible.

During operations the operating point of the up-and-down excursions is constantly changing, while remaining in the negative area. The negative counteracting potential varies with the signal and is effective wherever the operating point may be. The more rapid the accumulation of negative ions on condenser plate *a* the more rapid will be the downward movement of the operating point. This has the effect of preventing any positive excursion from going beyond the point where appreciable distortion would begin, as at K in Fig. 2.

I have here, also, the application of negative ions to counteract the tendency of the grid or control element to become unduly

positive. In other words, the control of the positive swing is by means of free ions as distinguished from some other kind of potential.

With respect to the leakage through the ohmic resistance *9* which is adapted to limit the downward swing, while leakage at this element is taking place at all times the device is in operation with a signal impressed on the grid, such leakage is more rapid (owing to the then higher potential) when the accumulation of ions on the condenser plate *a* is relatively great. Such accumulation, as stated, moves the operating point to a lower position, but the ensuing rapid leakage tends to move the point of operation upward. The effect is that the operating point is moved downward until a balance of these opposing influences is reached, that point depending upon the amplitude of the signal at the time. The point of operation may move quite suddenly downward, but it will stop in this downward course far above the point F of Fig. 2, and this results from the adjustment of leak *9* which provides for such a rapid discharge under accumulated potential on plate *a* as to hold the point of operation from moving too low.

This condenser and leak device is thus a regulator or control for both the positive and the negative excursions. As a unit it prevents these excursions from extending into the respective fields to a position where material or substantial distortion of the signal would occur.

The low ohmic resistance of the secondary as *2* extends the available range on the positive side. I have thus, according to this system, an unusually wide range for the substantially non-distortional effects desired.

Turning to the second stage in Fig. 1, the input circuit may be considered the same as in the first stage except for the valve 39, which, as illustrated, but without limitation, is a two-electrode tube known as a Fleming valve. It has a filament 40 and plate 43. I provide also a direct current negative voltage for the plate shown as a battery 44. In the later stages of amplification the signal amplitudes are relatively great. Such signals can be amplified properly according to the first stage, but in view of the larger amounts of power current involved in the later stages, with correspondingly greater fluctuations thereof, I consider it more satisfactory to withhold leakage of the electronic charge on plate *m* of condenser 37 until it has reached some predetermined negative potential beyond which distortion on the negative side is likely to occur. This value is determined by battery 44, the negative terminal of which is connected to anode 43 of the unidirectional current device of which it forms a part.

Let us assume a negative potential of ten



volts impressed by battery 44 on anode or plate 43. As is well known, no current will flow from battery 44 across the space between anode 43 and cathode 40. In such a device there is no current flow unless the anode 43 is positive to cathode 40. Now, when the negative charge on condenser plate 37 exceeds the ten volts negative impressed on the anode the anode becomes positive to the cathode and an ionic discharge between cathode 40 and anode 43 takes place.

The valve device just described is a modified form of leak operating similarly to leak 9 but becoming effective only when the condenser charge exceeds a predetermined value.

The blocking battery 44 has no function or effect other than to determine the limit of accumulated potential on condenser 37. Its voltage never reaches the grid 34 or filament 21, and no current from battery 44 flows at any time through triode 21 or between any of its elements. In short, battery 44 has no current flow.

As in the first stage, this condenser and leak 37-39 is a device which controls both the positive and negative excursions of the grid potential and limits the extremities thereof to the substantially non-distortional range.

The voltages of battery B will vary for different stages, according to the tubes employed, etc., but will ordinarily be from twenty-five percent to fifty percent less than those usually employed in other types of amplifiers.

I contemplate as being included in the present invention all such changes, variations and departures from what is specifically illustrated and described herein as fall within the scope of the appended claims.

I claim:

1. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode, an input transformer secondary of materially low ohmic resistance included in said circuit, and means in series with one of said triode elements and said secondary for limiting the excursions of positive excursions of the control element potential.

2. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode, an input transformer secondary of materially low ohmic resistance included in said circuit, and means in series with one of said triode elements and said secondary for limiting the extremities of positive and negative excursions of the control element potential.

3. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element

and the control element of a thermionic triode, an input transformer secondary having a resistance of less than one thousand ohms included in said circuit, and means in series with one of said triode elements and said secondary for limiting the positive excursions of the control element potential.

4. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode, an input transformer secondary having a resistance of less than five hundred ohms included in said circuit, and means in series with one of said triode elements and said secondary for limiting the positive excursions of the control element potential.

5. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode, an input transformer secondary having a resistance of less than three hundred ohms included in said circuit, and means in series with one of said triode elements and said secondary for limiting the positive excursions of the control element potential.

6. In an amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode, an input transformer secondary having a resistance of less than one thousand ohms included in said circuit, and means in series with one of said triode elements and said secondary for limiting the extremities of the positive and negative excursions of control element potential.

7. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode and input transformer secondary included in said circuit, said secondary having an ohmic resistance as low as to provide for a materially great range of substantially non-distortional positive excursions of the control element potential, and means for limiting such positive excursions substantially to such substantially non-distortional range.

8. In an audio-frequency amplifier, an input circuit including the electron-emitting cathode and the control element of a thermionic triode, an input transformer secondary included in said circuit and being of materially low ohmic resistance to provide a materially great range of substantially non-distortional positive excursions of the control element potential, said circuit including means forming a path for signal voltage from one pole of the transformer secondary to said control element and means

forming another path for such voltage from the other pole of said secondary to said cathode, one of said paths including an electrostatic condenser and a leak in shunt with said condenser.

9. In an audio-frequency amplifier, an input signal-amplifying circuit which includes a thermionic device having an electron-emitting element, a control element and an output element, and means in said circuit including an input transformer secondary of materially low ohmic resistance for providing a materially great substantially non-distortional range of positive excursions of the control element potential.

10. In an audio-frequency amplifier, an input signal-amplifying circuit which includes a thermionic device having a control element and an electron-emitting element, means external to the thermionic device and in said circuit for providing a substantially great range of positive excursions of the control element potential, and means for automatically limiting such positive excursions to substantially a non-distortional range.

11. In an audio-frequency amplifier, an input signal-amplifying circuit which includes a thermionic device having an electron-emitting element, a control element and an output element, said circuit including also an input transformer secondary of materially low ohmic resistance, and means for automatically shifting positively the point of operation of said control element potential during negative excursions respectively.

12. In an audio-frequency amplifier, an input signal-amplifying circuit which includes a thermionic device having an electron-emitting element, a control element and an output element, said circuit including also an input transformer secondary of materially low ohmic resistance, and means for alternately shifting in the positive and negative directions the point of operation of excursions of the control element potential to maintain the limits of the negative and positive excursions respectively within a substantially non-distortional range.

13. In an audio-frequency amplifier, an input signal-amplifying system which includes a thermionic device having an electron-emitting element, a cathode element and an output element, a transformer secondary of materially low ohmic resistance in said circuit and means for controlling an excursion of the control element potential by shifting the point of operation of the control element potential in a direction opposite to the potential of the excursion.

14. In an audio-frequency amplifier, an input circuit which includes a thermionic device having grid, plate and cathode elements, a transformer input secondary of materially low ohmic resistance, and means for

controlling the excursions of the signal potential of the grid element, said means comprising a capacity device in said circuit and a materially high resistance leak shunting said capacity device.

15. In an audio-frequency amplifier, an input signal-amplifying system employing a thermionic device having grid, plate and cathode elements, a transformer secondary of materially low ohmic resistance in said circuit, and means for controlling the excursions of the signal potential of the grid element, said means comprising a capacity device in said circuit and a unilateral current-conducting device in shunt with said capacity device together with means for automatically controlling the action of said current-conducting device.

16. In an audio-frequency amplifier, an input circuit including the control element and the electron-emitting element of a thermionic triode and including a materially low ohmic resistance source of signal oscillations, with means for controlling the excursions of the control element potential including an electrostatic condenser in series with said source and with one of said elements, a two-electrode tube serving as a one-way valve having cathode and anode and being in shunt with said condenser, and a source of direct-current potential in series with said anode and one side of said condenser, the potential of said current source serving to determine the potential at which said condenser will discharge between the cathode and the anode of said valve.

17. In an audio-frequency amplifier, an input circuit including the control element and the electron-emitting element of a thermionic triode and including a materially low ohmic resistance source of signal oscillations, with means producing a controllable ionic potential for automatically shifting the operating point of the control element potential in a direction opposite to the potential of the excursion.

18. In an audio-frequency amplifying system of the character described, an input circuit including the electron-emitting element and the control element of a thermionic triode, an input transformer secondary in said circuit and having an ohmic resistance so low as to provide for a materially great range of substantially non-distortional positive excursions of the control element potential, with an electrostatic condenser in said circuit and between said electron-emitting element and said secondary, and a resistance leak shunting said condenser.

RAYMOND T. CLOUD.

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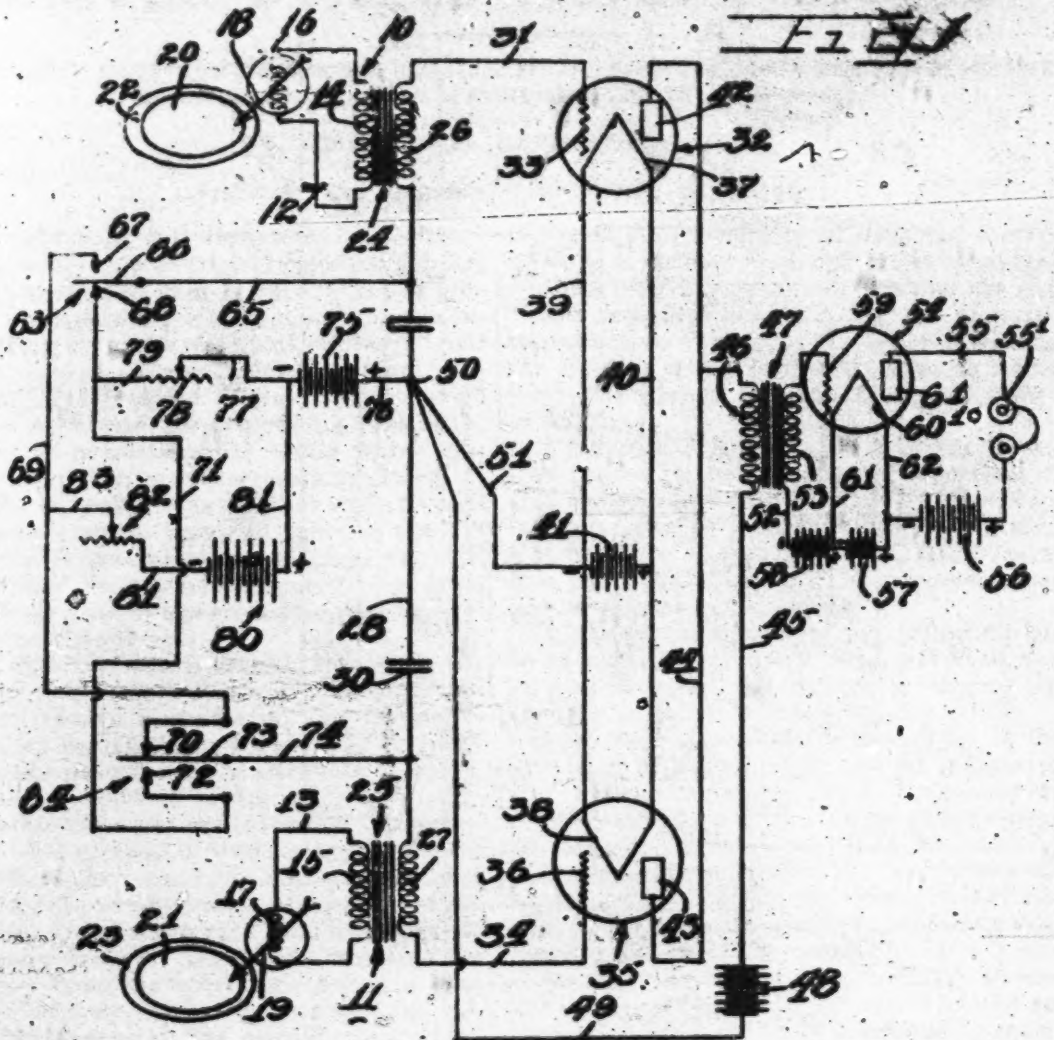
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1,864,890

ELECTRICAL REPRODUCER

Filed Nov. 19, 1927

2 Sheets-Sheet 1



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June 26, 1932.

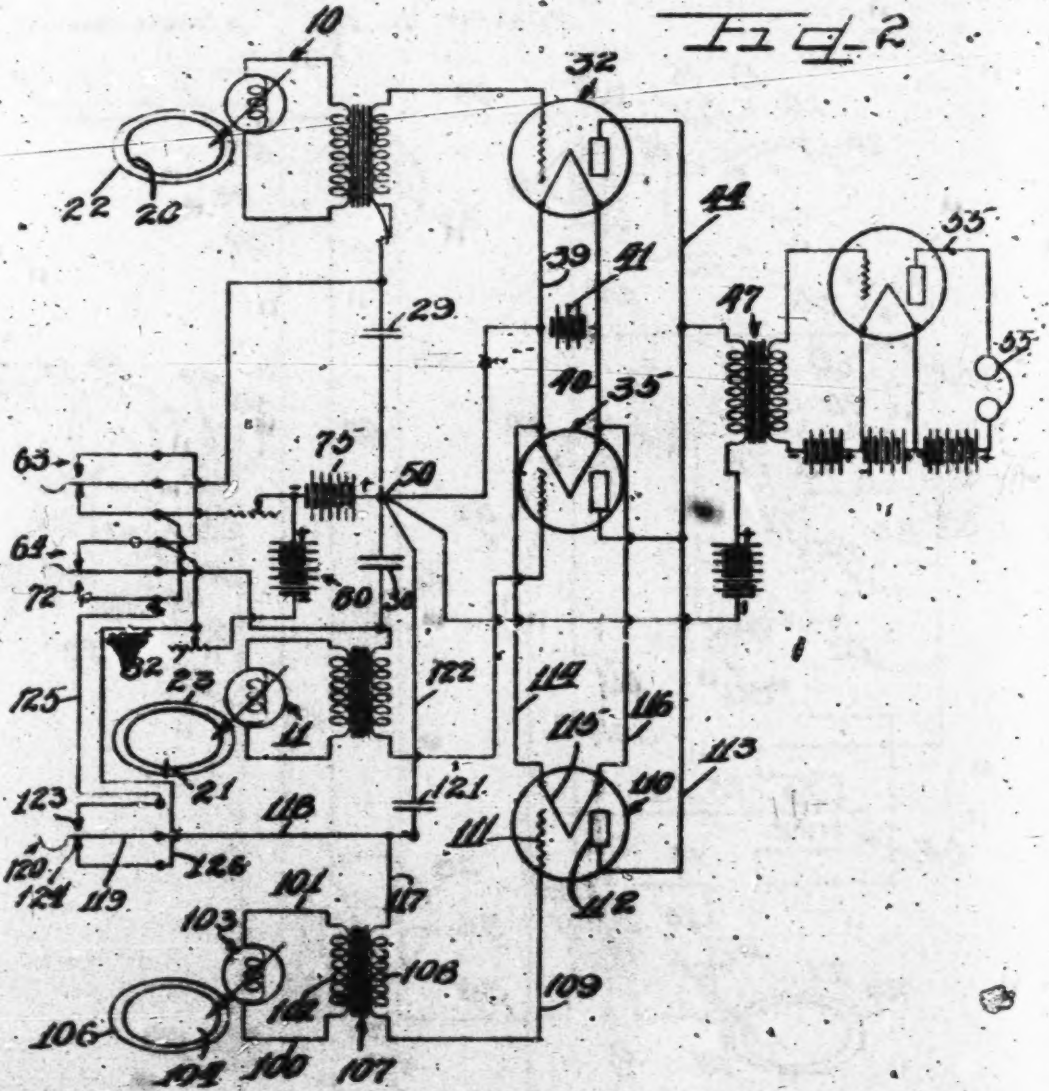
R. T. CLOUD

1,864,890

ELECTRICAL REPRODUCER

Filed Nov. 19, 1927

2 Sheets-Sheet 2



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Patented June 28, 1932

1,164,890

## UNITED STATES PATENT OFFICE

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## ELECTRICAL REPRODUCER

Application filed November 18, 1927. Serial No. 284,257.

My present invention pertains to electrical reproducing apparatus, and more particularly to a method of and an apparatus for contemporaneously reproducing, in a single reproducing unit, the electrical impulses from a plurality of different sources. More specifically, the invention relates to a method of and an apparatus for controlling the reproduction of music or other sound waves in a single reproducing unit from a plurality of records, in such a manner that even though the records might be at all times in contact with the respective electrical pick-ups, still music may be reproduced selectively from any one or more of the records as desired, and not from the others.

An object of my invention resides in the provision of a method of and an apparatus for electrically reproducing the waves recorded on records in such a manner that any one of the records may be alternately and selectively reproduced as desired.

Another object of my invention is the provision of a method of and an apparatus for controlling the reproduction of waves from a plurality of records in such a manner that the impulses from one record can be caused to gradually decrease in volume, whereas the impulses from the other record can be contemporaneously gradually increased in volume, thus enabling the reproduction of an electrical wave which is the resultant wave of the different set of impulses.

Still another object of my invention has to do with the provision of a method of and an apparatus for electrically reproducing the waves recorded on a plurality of records in such a way that these records can be alternately reproduced without the detection of the change from one record to the other.

A further object of my invention is the provision of a method of and an apparatus for electrically reproducing the waves recorded on a plurality of records in such a manner that the reproduction is a resultant wave in which the components are overlapping impulses from the different records.

A still further object of my invention is the provision of a method of and an apparatus for electrically reproducing the music

recorded on a plurality of different records in such a manner that the music produced consists of overlapping waves from the different records, thus enabling the alternate reproduction of each of the records without the listener being ordinarily able to detect when the change is made from one record to another.

Another and further object of my invention resides in the provision of a method of and an apparatus for controlling or delaying the action of a thermionic valve in such a manner that it does not become fully operative or inoperative until a predetermined period of time has elapsed.

A still further object of my invention has to do with the provision of a method of and an apparatus for exponentially varying the electron emission in a thermionic valve.

A further object of the invention is the provision of a method of and an apparatus for reproducing sound from a plurality of phonograph records in a single sound reproducing unit, in such a way that the intensity of the sound from each of the several records may be varied, while the intensity, of the sound emitted by the single reproducing unit remains substantially constant.

Another important object of my invention is the provision of a method of and an apparatus for electrically reproducing musical waves from records as well as the reproduction of the illusion of approaching and receding bodies so that while one record is providing the music, another may be brought into play to reproduce the whistling of a locomotive, the ringing of bells and the like.

A still further object of the invention resides in the provision of a method of and an apparatus for controlling the transfer of power from two different electrical sources, each capable of a relatively constant input, to a common receiver through two thermionic tubes in such a manner that the electronic emission in one of the tubes may be increased, while the electronic emission in the other of the tubes is being decreased and yet at the same time enable the total output of the tubes to the common receiver to remain substantially constant in volume while



one of the sources is being switched into operative association with the receiver and the other of the sources is being switched out of operative association with the receiver.

In accordance with the general features of the present invention, I provide a sound reproducer having two record turntables with a record on each, electrical pick-up means in operative association with the records, electrical sound transmitting means connected to a reproducing unit, and means including an electrical circuit for controlling the sound output of the pick-ups and for increasing the output of one pick-up while decreasing the output of the other pick-up to electrically produce sound in the reproducing unit from either record as desired.

Other objects and advantages of my invention will more fully appear from the following detailed description taken in connection with the accompanying drawings, which illustrate several embodiments thereof and in which:

Figure 1 is a diagrammatic view illustrating a novel electrical circuit embodying the features of my invention, and

Figure 2 is a diagrammatic view similar to Figure 1 illustrating the circuit as being provided with an additional input device adapted to be operated when it is desired to reproduce the illusion of an approaching or receding train or the like by the whistling of a locomotive.

It is thought that my novel method of electrically reproducing waves will be evident from a description of an apparatus by which the process may be practiced.

In the drawings:

Like reference characters designate similar parts throughout the several views.

The reference characters 10 and 11 designate generally the input devices of my novel electrical circuit. Each of these devices comprises a circuit 12-15, which includes a primary transformer winding 14-15, and a pick-up resistance 16-17. The two resistances 16 and 17 comprise parts of electrical pick-ups designated generally by the reference characters 18 and 19.

These electrical pick-ups may be of any conventional construction. These devices 18 and 19 are operatively associated with the records to be electrically reproduced. In accordance with the features of a preferred embodiment of my invention, I have illustrated these pick-ups as being operatively associated with phonograph records 20 and 21. These phonograph records are mounted on turntables 22 and 23, which may be rotated by any suitable means, such, for example, as electrical motors (not shown), as is well known in the art. Also it is to be noted that my invention permits of both of these turntables rotating contemporaneously throughout the period of time that music is

being reproduced. As will be more fully explained hereinafter, when one record is being reproduced, another record may be placed on the other rotating table in a condition ready to be reproduced when the pick-up associated with the former record is rendered ineffective.

The primary windings 14 and 15 comprise parts of transformers designated generally by the reference characters 24 and 25. The secondary windings 26 and 27 of these two transformers 24 and 25 are connected by a common lead wire 28, in which is interposed a pair of fixed condensers 29 and 30, the purpose of which will be more fully described in connection with the operation of my circuit. It will also be noted that the transformer winding 26 is connected by a conductor 31 with the grid 32 of a thermionic tube 33, and that the winding 27 is connected by a conductor 34 to the grid 35 of another thermionic tube 35. The filaments 37 and 38 of the two tubes 33 and 35, respectively, are connected together by conductors 39 and 40. Connected in parallel to the conductors 39 and 40 is an A-battery 41.

The plates 42 and 43 of the two tubes 33 and 35, respectively, are connected by means of a common lead 44. Connected to this lead 44 between its ends is one end of a conductor 45, including the primary winding 46 of an output transformer 47. The other end of the conductor 45 is connected to one side of a battery 48. The other side of the battery is connected by a conductor 49 to a point 50 in lead wire 28. It will also be noted that a conductor 51 connects this point 50 with the negative side of A-battery 41.

The secondary winding 52 of output transformer 47 comprises part of an electrical reproducing or receiving circuit 53, which includes an amplifier tube 54, a head set or loud speaker 55 and A, B and C batteries 56, 57 and 58. The tube 54 is a conventional three element tube and includes a grid 59, a filament 60 and a plate 60. The filament 60 is connected by leads 61 and 62 to A-battery 57.

I shall now proceed to describe in detail the control mechanism, including the switches, for controlling the electron emission in tubes 33 and 35, whereby the music reproduced in the circuit 53 may be selectively controlled. The lead 28 has connected to it, adjacent condenser 29, one end of a conductor 63, the other end of which is connected to a switch element 65 adapted to cooperate with switch points 67 and 68. The switch point 67 is connected to one end of a conductor 69, the other end of which terminates in a switch contact point 70 of another switch. The switch point 68 is connected by a conductor 71 to the switch point 73 of said other switch. These switch points 70 and 73 are adapted to cooperate with a

switch element 73 connected by a conductor 74 to circuit lead 92. I have designated generally the two switches above described by the reference characters 63 and 64.

A bias battery 75 is connected on one side by a conductor 76 to point 80, previously described, in lead 28. The other side of battery 75 is connected by a conductor 77 to a variable resistance 78, which is connected by a conductor 79 to an intermediate part of conductor 71. The conductor 77 has secured to it one end of conductor 81, which is electrically connected to one side of a C bias battery 80, which I shall hereinafter refer to as a blocking battery. The other side of this battery is connected by a conductor 81 to a variable resistance 82 connected by a conductor 83 to an intermediate point in lead 69.

From the foregoing, it will be evident that there are two C bias batteries adapted to be electrically connected to the grids 33 and 36 of tubes 32 and 35. The C battery 75 is adapted to be connected to either of these grids for the normal operation of the associated tube, whereas the C battery 80 is adapted to be connected to either of these grids for the purpose of blocking the action of the associated tube or valve. Attention is also directed to the fact that the switches 63 and 64 are adapted to be operated, as will be more fully explained hereinafter, to control the selective operation of thermionic tubes 32 and 35, so that these tubes may be alternately connected to the reproducing or receiver circuit 55.

The resistances or resistors 78 and 82 are designed to control the rate that condensers 29 and 30 are charged and discharged, so as to enable the selective control of the blocking out of the tubes 32 or 35, as well as the setting into action of these tubes.

The C bias battery 75 is intended to be of such capacity as to provide the normal amount of voltage needed to charge the grids 33 and 36 of tubes 32 and 35 without overloading or blocking them, whereas the C bias battery 80 is of such a capacity as to be capable of providing sufficient voltage to these grids as to overload them and thus prevent their normal operation.

The operation of my novel circuit is briefly as follows:

When the switches 63 and 64 are in the positions shown in Figure 1, the blocking battery 80 will be connected so as to charge condenser 30, and the normal battery 75 will be connected to the grid 33 of tube 32. It will be evident that the blocking battery 80 will charge the condenser 30 and give the grid 36 of tube 35 a charge of the proper intensity to block the emission of electrons from the filament 36 to the plate 43 of tube 35, thus rendering this tube inoperative as an amplifier or relay. Of course, it is to be under-

stood that the rate at which the potential of grid 36 is built up depends upon the rate at which condenser 30 is charged. This rate, of course, will be controlled by the position of the resistor 82. That is to say, upon the initial connection of blocking battery 80 to condenser 30 and grid 36, the resistor 82 will serve as a means to delay the building up of the overloading potential of grid 36. In other words, the resistor 82 permits of the tube 35 being gradually rendered inoperative by the building up of the potential on grid 36 from battery 80. However, it is to be remembered that this feature would not be possible if it were not for the condenser 30, which is charged at a predetermined rate depending upon the position of resistor 82. Furthermore, I find that the rate at which the potential on grid 36 is built up may be plotted graphically, and that the resultant curve takes the form of an exponential curve.

Obviously by gradually building up the potential of grid 36, it is possible to gradually decrease the electronic emission in the tube 35 between the plate and the grid thereof. In fact, this electronic emission decreases exponentially.

In Figure 1 it will also be observed that the battery 75 is connected through switch 63 to the grid 33 of tube 32. This battery serves to supply a voltage sufficient for the normal operation of tube 32.

It will also be evident from Figure 1 that when tube 32 is operative, the waves entering the transformer 10 from the pick-up device 18 will be amplified and reproduced in the receiver or reproducing circuit 55. On the other hand, the rendering inoperative of the tube 35 will prevent any reproduction of the waves entering transformer 11 from pick-up device 19.

When the record 20 on turntable 22 has been substantially reproduced in the receiver circuit 55, or when it is desired to change from the record 20 to the record 21 on turntable 23, it will be necessary to operate switches 63 and 64, so as to move contact element 66 into cooperation with switch point 67 and contact element 73 into cooperation with switch point 72. It will, of course, be evident that the operation of these two switches 63 and 64 may be accomplished contemporaneously by the means of a suitable cam key or the like, such as is well known in the art. In any event, it is desirable to operate these two switches at the same time, and hence the switch arms or elements 66 and 73 should be mechanically connected together.

This operation of the switches 63 and 64 will result in the blocking battery 80 being connected to condenser 29 and grid 33 of tube or valve 32, and the normal battery 75 being connected to grid 36 of tube or valve 35. Also it will be evident that the condenser 30 will no longer be charged by the overload



battery 80 and hence will begin to discharge through the resistor 78. The rate at which this condenser discharges can be controlled exponentially by the resistor 78. Obviously by gradually causing the condenser 30 to discharge, the overload potential on grid 33 will gradually decrease, thus allowing the tube 32 to be gradually brought into operation. When the condenser 30 has become discharged to such an extent that the grid 33 has a normal potential, the normal battery 75 will function to maintain this normal potential in this grid.

By connecting the overload C bias battery 80 to the condenser 30, the potential on grid 33 of tube 32 will be gradually increased, thus causing the amplifying action of this tube to be proportionately diminished. In other words, the electronic emission in the tube 32 can be gradually decreased, thus decreasing the intensity of the waves reaching the receiving circuit 55 from the pick-up 18. When the condenser 30 has become fully charged by the blocking battery 80, the tube 32 will have been rendered completely inoperative.

From the foregoing, it will be evident that one tube can be gradually brought into operation, and the other tube can be gradually rendered inoperative. This means that the electrical waves reaching the circuit 55 from one pick-up will gradually decrease in intensity, while the electrical waves from the other pick-up will gradually increase in intensity. The wave reproduced in the loud speaker or head set 53' will be a resultant of these two sets of varying waves or impulses. Thus, it will be evident that when one record is brought into play, the music reproduced therefrom will override the impulses coming from the tube which is gradually being blocked by battery 80. This overlapping feature is desirable for the reason that it prevents the listener from being ordinarily able to detect when the change is made from one record to another. That is to say, the records 20 and 21 can be alternately reproduced in the receiving circuit 55 without the detection of the change from one record to the other. As previously pointed out, at the time this change is made the music coming from the head set 53' will comprise a resultant wave, in which the components are the overlapping impulses from the two amplifying tubes 32 and 33.

It is evident from the foregoing, that as soon as a record has been blocked out so that reproduction from this record has ceased, the pick-up may be removed from contact with that record and another record may be substituted for it, and the pick-up may be placed in contact with the substituted record. Each of the pick-ups is so arranged that it may be removed from contact with the associated record at any time and moreover this may be

accomplished either manually or automatically as desired by the operator.

The records 20 and 21 are illustrated as being of the ordinary disc type, which may be rotated with the turntables 22 and 23 by any suitable means such, for example, as the conventional electric motor. It is, of course, apparent that the present invention is not to be limited in its application to the use of such disc records, for obviously the invention may be employed in connection with cylinder records or to any records upon which sound waves or other waves to be reproduced have been recorded, irrespective of the manner in which these waves are recorded. As previously pointed out, the pick-ups 18 and 19 may be of any suitable type adapted to receive the recorded impulse and to transform it into an electrical impulse.

In Figure 2 I have illustrated a modification of my invention, wherein an additional input device 100 is connected so as to modulate the electrical current flowing in the amplifying circuit. Inasmuch as the circuit associated with the other two input units shown in Figure 2 operates in identically the same way as that shown in Figure 1, the same reference characters will be applied to the elements comprising this circuit as were used in connection with Figure 1. Different reference characters will be applied to the parts of the circuit shown in Figure 2 used to couple the third input device 100 to the other circuit. The input device 100 comprises a circuit 101 including a primary transformer winding 102 and a resistance 103 comprising part of an electrical pick-up device 104. The pick-up device is operatively associated with a disc record 105 of the phonograph type disposed on a rotatable turntable 106.

The winding 102 constitutes part of a transformer 107, which also includes a secondary winding 108. One end of this winding 108 is connected by a conductor 109 to the grid 111 of an amplifying tube or valve 110. The plate 112 of this tube is connected by a conductor 113 to conductor 44 connected to the plates of the other two tubes 32 and 33. The filament 115 of this tube is connected by conductors 114 and 116 to the leads 39 and 40 connecting the filaments of the tubes 32 and 33. In other words, the filament 115 is so connected as to receive current from the A battery 41 common to filaments of tubes 32 and 33.

The other end of transformer 108 is connected by a short length of wire 117 to a conductor 118. One end of this conductor 118 is secured to a switch element or arm 119 of a switch 120. The other end of this wire 118 is connected to a fixed conductor 121 which is connected by wire 122 to point 50 of the main circuit.

The switch 120 includes a pair of oppositely disposed contacts 123 and 124 cooperable with

switch element 119. One of these contacts 123 is connected by a conductor 125 to switch contact 72 of switch 64. The other switch contact 124 is connected by a conductor 126 to resistor 82.

The operation of this additional input device 100 and the associated amplifying tube 110 is briefly as follows:

The switch element or arm 119 is shown in a position (Figure 2) wherein it is in engagement with contact 124 and hence resistor 82. The grid 111 of tube 110 being connected to the overload C battery 80 through the resistor 82. This means that the grid 111 is provided with a high potential that the action of tube 110 is blocked. When it is desired to render the tube 110 operative so as to enable the reproduction of the music on record 105 in the receiving circuit 55, the same may be accomplished by moving switch element 119 out of cooperation with contact 124 and into engagement with contact 123. This will result in the grid 111 being disconnected from the blocking battery 80 and being connected to the normal C bias battery 75. Of course, it is to be understood that the minute switch arm 119 has moved out of cooperation with contact 124, the condenser 121 will begin to discharge. As the condenser 121 discharges, the potential on grid 111 is gradually decreased, thus resulting in the tube 110 gradually becoming operative. In fact, the rate of the electronic discharge in the tube between the plate 112 and the filament 115 will follow substantially an exponential curve. After the condenser 121 has discharged to a sufficient extent to cause grid 111 to have a normal potential, the tube 110 will become fully operative.

Thereafter, when it is desired to render the tube 110 inoperative, the same may be accomplished by moving switch arm 119 back into engagement with contact 124 of switch 120. This will mean that the blocking battery 80 will begin to gradually charge condenser 121 through resistor 82. Obviously since the condenser 121 is in conductive connection with the grid 111, it necessarily follows that the condenser 121 and the grid 111 will have the same potential when the blocking battery 80 is charged thereto. As the charge in the condenser 121 gradually builds up, the potential of grid 111 will also gradually increase, thus resulting in a gradual decrease in the electronic activity of the tube. In other words, the tube 110 will be gradually rendered inoperative. Moreover, by diminishing the electronic emission in tube 110, the intensity of the impulses from pick-up device 104, transmitted to the receiving circuit 55 by this tube, will be gradually diminished. Thus, the music reproduced in the receiving circuit 55, from disc 105, will gradually die out until the tube 110 is rendered completely inoperative.

This third input device 100 can be utilized to musically produce the illusion of approaching and receding bodies. For example, the record 105 may have recorded thereon impulses corresponding to the whistling of a locomotive, the hoofbeats of a horse, the ringing of bells and the like, all of which may be reproduced to produce a given illusion. That is to say, while one of the records 90 or 91 is providing the music, such as is required in connection with a given scene of a moving picture, the record 105 can be gradually reproduced in the receiving circuit 55 to produce an illusion in connection with the music being heard.

Now, of course, it is to be understood that although I have illustrated and described in detail the preferred forms of my invention, the invention is not to be thus limited, but only in so far as defined by the scope and spirit of the appended claims.

I claim as my invention:

1. In combination, an electrical circuit, an electrical reproducing unit in said circuit, a plurality of input devices connected to said unit by said circuit adapted to each set up electrical impulses in said circuit, means connected to said circuit for selectively causing said devices to be connected to said unit, and means controlled by said selective means and connected to said circuit for automatically causing the devices to at times apply overlapping impulses to said unit, whereby said unit is subjected to an electrical resultant wave, in which wave the impulses from said devices are the components, said latter means including a plurality of amplifying elements and means for simultaneously increasing the output of one of said elements and decreasing the output of another element.

2. In combination, an electrical circuit, an electrical reproducing unit in said circuit, a plurality of input devices connected to said unit by said circuit adapted to each set up electrical impulses in said circuit, means connected to said circuit for selectively causing said devices to be connected to said unit, and electronic means controlled by said selective means and connected to said circuit for causing the devices to at times apply overlapping impulses to said unit, whereby said unit is subjected to an electrical resultant wave, in which wave the impulses from said devices are the components, said latter means including a plurality of electrical valves receiving energy from said input devices and electrical means for decreasing the electron emission in one of said valves and for increasing the electron emission in another of said valves.

3. In combination, an electrical circuit, an electrical reproducing unit in said circuit, a plurality of input devices connected to said unit by said circuit adapted to each set up electrical impulses in said circuit, means con-



ected to said circuit for selectively causing said devices to be connected to said unit, and means controlled by said selective means and connected to said circuit for causing the devices to at times apply overlapping impulses to said unit, whereby said unit is subjected to an electrical resultant wave, in which wave the impulses from said devices are the components, said latter means including a plurality of amplifying tubes adapted to receive energy from said input devices and electrical means including condensers adapted to contemporaneously increase the electron emission in one of said tubes and to decrease the electron emission in another of said tubes.

4. In combination, an electrical circuit, an electrical reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, means connected to said circuit for selectively causing said devices to be connected to said unit, and means controlled by said selective means and connected to said circuit for causing the devices to at times apply overlapping impulses to said unit, whereby said unit is subjected to an electrical resultant wave, in which wave the impulses from said devices are the components, said latter means including a plurality of electron tubes, energy storing means connecting said tubes to said input devices and energy discharging means connected to said tubes for contemporaneously increasing the electron emission in one of said tubes and for decreasing the electron emission in another of said tubes.

5. In combination, an electrical circuit, a reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, electron tubes in said circuit for amplifying the impulses delivered to said unit, and means for blocking the action of said tubes and adapted to contemporaneously cause one of said tubes to be gradually brought into operation and another tube to be gradually blocked from operation.

6. In combination, an electrical circuit, a reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, electron tubes in said circuit for amplifying the impulses delivered to said unit, means for blocking the action of said tubes and adapted to contemporaneously cause one of said tubes to be gradually brought into operation and another tube to be gradually blocked from operation, and means for controlling this gradual blocking of the tubes.

7. In combination, an electrical circuit, a reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable

electrical impulses in said circuit, electron tubes in said circuit for amplifying the impulses delivered to said unit, and means for blocking the action of said tubes and adapted to contemporaneously cause one of said tubes to be gradually brought into operation and another tube to be gradually blocked from operation, said tubes each including a grid, said latter means including a plurality of condensers, there being one connected to each tube grid.

8. In combination, an electrical circuit, a reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, electron tubes in said circuit for amplifying the impulses delivered to said unit, means for blocking the action of said tubes and adapted to contemporaneously cause one of said tubes to be gradually brought into operation and another tube to be gradually blocked from operation, and means for controlling this gradual blocking of the tubes, said blocking means including a plurality of condensers connected to the tubes and said last mentioned control means including a plurality of resistors for controlling the action of the condensers.

9. In combination, an electrical circuit, a reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, electron tubes in said circuit for amplifying the impulses delivered to said unit, means for blocking the action of said tubes and adapted to contemporaneously cause one of said tubes to be gradually brought into operation and another tube to be gradually blocked from operation, said latter means including a plurality of condensers, battery means for charging these condensers adapted to supply the necessary voltage for overloading the tubes, and resistors for controlling the charging of the condensers by said battery means.

10. In combination, an electrical circuit, an electrical reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, means connected to said circuit for selectively causing said devices to be connected to said unit, and means controlled by said selective means and connected to said circuit for contemporaneously causing the devices to at times apply overlapping impulses to said unit, whereby said unit is subjected to an electrical resultant wave, in which wave the impulses from said devices are the components, each of said input devices including a circuit to be reproduced and pick-up means electrically connected to said circuit and at all times in operative association with the record.

11. In combination, an electrical circuit, an electrical reproducing unit in said circuit, a plurality of variable input devices connected to said unit by said circuit adapted to each set up variable electrical impulses in said circuit, means connected to said circuit for selectively causing said devices to be connected to said unit, and means controlled by said selective means and connected to said circuit for automatically causing the devices to at times apply overlapping impulses to said unit, whereby said unit is subjected to an electrical resultant wave, in which wave the impulses from said devices are the components, each of said input devices including a record turntable, a record on the table and electrical pick-up means connected to the circuit and at all times in operative association with the record on the turntable.

12. In an electrical circuit a thermionic tube including a grid, an electrical pick-up connected to said grid, a source of energy, energy storing means and energy flow resisting means adapted to exponentially increase an electric charge on the grid of the tube to gradually block out the transmission of wave impulses from said pick-up.

13. In an electrical circuit a thermionic tube including a grid, an electrical pick-up connected to said grid, a source of energy, energy storing means and energy flow resisting means adapted to exponentially decrease an electric charge on the grid of the tube to gradually cause said tube to transmit wave impulses from said pick-up.

14. In an electrical circuit a thermionic tube, an electrical pick-up connected to said tube, a source of energy, condenser means connected to said source, and resistor means connected to said condenser means adapted to exponentially vary the electron emission in the tube so as to vary the transmission of wave impulses from said pick-up through said tube.

15. In combination, a thermionic tube including a grid, an electrical pick-up connected to said grid, and means connected to said grid for gradually energizing said grid beyond the operable capacity of said tube, whereby the action of said tube is gradually blocked to prevent transmission of electrical waves from said pick-up.

16. In combination, a plurality of means adapted to receive and transmit electrical impulses, means for transforming said electrical impulses into audible sound waves, an electrical circuit connecting said receiving means to said transforming means, and means connected to said circuit and acting between said receiving means and said transforming means for automatically and selectively increasing the intensity of the impulses from one receiving means and simultaneously decreasing the intensity of the impulses from another of said receiving means,

whereby grid transforming means may be subjected to an electrical resultant wave, in which wave the impulses from each of said receiving means are the components.

17. In a record playing machine having two record turntables and a record on each of the said turntables, two available arms, an electric pick-up connected to each of the said arms in operative association with a record, a tone chamber, electric sound transmitting means connected to the tone chamber, means to rotate the said turntables, an electric circuit operatively connecting both of the pick-ups, and means in the said circuit automatically operable upon the closing of the circuit for controlling the sound output of the said pick-ups, and for automatically increasing the output of one pick-up while decreasing the output of the other pick-up to electrically produce sound in said tone chamber from either record as desired.

18. The combination of music synchronizing means for phonographs with two record tables, a record on each of the tables, arms including electric pick-ups in operative association with the said records, and two thermionic amplifiers in a circuit with the said pick-ups, the said means being automatically operable upon the closing of the circuit to gradually increase the electron emission in one of the said amplifiers while gradually decreasing the electron emission in the other of the said amplifiers so as to gradually increase the volume of sound transmitted to a tone chamber from one of the pick-ups and to decrease the volume of sound transmitted to a tone chamber from the other of the pick-ups.

19. In combination, a plurality of records, a plurality of thermionic tubes having grids therein, pick-up means in operative association with the said records and the said tubes, electrical storing means and electrical dissipating means cooperating with a grid in one tube to exponentially increase the electron emission in the said tube, and cooperating with a grid in another tube to exponentially decrease the electron emission in the latter named tube so that the emission in the first named tube is increasing while that in the latter named tube is decreasing.

20. In combination, a plurality of records, thermionic tubes having grids therein, pick-up means in operative association with the said records and the said tubes, electrical storing means and electrical dissipating means cooperating with a grid in one tube to increase the electron emission in the tube, and cooperating with a grid in another tube to decrease the electron emission in the latter named tube while the electron emission in the first named tube is increasing so that the total output of the tubes may be maintained substantially constant while the energy input to the tubes from the pick-up means remains constant.



21. An energy transfer device of the class described, comprising a plurality of thermionic tubes, each having a grid therein, electrical input means in operative association with the said tubes, a source of electrical power, energy storing means connected thereto, energy dissipating means, and switch means adapted to connect the said energy source, and the said energy storing means and the said energy dissipating means in operative association with the said grids to exponentially increase an electric charge on the grid of one tube while exponentially decreasing an electric charge on the grid of another tube.

22. The method of electrically modulating recorded impulses in a reproducing circuit, which consists upon the closing of the circuit in automatically increasing the intensity of one impulse, decreasing the intensity of another impulse, combining the impulses and transforming the resultant impulses into audible sound.

23. The method of automatically and electrically modulating a plurality of different sources of impulses upon the closing of a reproducing circuit, which consists in varying electrical currents by said impulses, amplifying the resulting currents, automatically increasing the intensity of one of said amplified currents, automatically decreasing the intensity of another of said amplified currents and combining said latter currents for reproduction.

24. The method of automatically and electrically modulating a plurality of different sources of impulses upon the closing of a reproducing circuit, which consists in varying electrical currents by said impulses, amplifying the resulting currents, automatically increasing the intensity of one of said amplified currents, automatically decreasing the intensity of another of said amplified currents and causing said varying currents to overlap each other as they are transmitted into audible sound.

25. The method of maintaining a substantially constant total output to a common receiver from two thermionic amplifying tubes cooperating with two pick-up means in operative association with phonograph records, which consists in exponentially decreasing the electron emission in one tube receiving energy impulses from one record through a pick-up while exponentially increasing the electron emission in the other tube receiving energy impulses from a record through the other pick-up.

26. The method of maintaining a substantially constant output from a plurality of amplifying means, which consists in exponentially decreasing the output of one of the said amplifying means while exponentially increasing the output of the other of the said amplifying means.

27. The method of varying the output of a plurality of thermionic amplifying tubes supplying energy to a common receiver, which consists in exponentially increasing the electron emission in one of the said tubes while exponentially decreasing the electron emission in the other of the said tubes and combining the resultant outputs of the tubes.

28. The method of automatically and electrically modulating impulses from a plurality of different records in a reproducing circuit when the circuit is closed, which consists in varying electrical currents by the recorded impulses, amplifying the resulting electrical currents, automatically controlling the amplification of said currents so as to enable the intensity of certain of said currents to be increased and the intensity of other currents to be contemporaneously decreased, combining said amplified currents of varying intensity and transmitting the resultant current into audible sound of comparatively constant volume.

29. The method of automatically and electrically modulating impulses from a plurality of different records in a reproducing circuit upon the closing of the circuit, which consists in contemporaneously varying electrical currents by the recorded impulses from independent sources, amplifying the resulting electrical currents so as to enable the intensity of one of said currents to be increased and the intensity of another of said currents to be decreased, automatically controlling the amplification of said currents so as to enable the impulses recorded on either of said records to be reproduced when desired, and transmitting the amplified currents into audible sound in such a manner that the change from one record to another cannot be ordinarily detected by the listener.

In testimony whereof I have hereunto subscribed my name at Chicago, Cook County, Illinois.

RAYMOND T. CLOUD.

NUMBER (Office of U.S.P.)

247422

(EXHIBIT BOOK)

235-A

DIV. 16

PATENT No. 1329283

PAT JAN 27 1920

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Invention *Audiotone-Thomson Amplifiers*

ORIGINAL		RENEWED	
Petition	<i>July 30</i> 1918		1918
Abstract	" " 1918		1918
Specification	" " 1918		1918
Drawing 2 sheets	" " 1918		1918
Photo Copy			1918
First Exam. Fee	<i>\$15. July 30</i> 1918		1918
" " (1918)			1918
Appl. filed complete	<i>July 30</i> 1918		1918
Examined and Passed for issue	<i>July 3</i> 1919		1919
Published	<i>July 3</i> 1919		1919
Notice of Allowance	<i>July 3</i> 1919		1919
Filed for Grant	<i>Dec 30</i> 1919		1919
" " (1919)			1919

*Residence not Uniform*

JAN 2 1920

Patented *Sept 11 1920*  
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U.S. of Claims Allowed (26) First Claim  
 Title as allowed *Thomson Amplifiers*

*Address*



1 *l c* TO ALL WHOM IT MAY CONCERN:

2 Be it known that I, HAROLD DEFOREST ARNOLD, a citizen  
 3 of the United States, residing at ~~East Orange~~ *Maplewood*, in the County of  
 4 Essex and State of New Jersey, have invented certain new and  
 5 useful improvements in *Thermionic Amplifiers*, of which the following is a  
 6 full, clear, concise, and exact description.

7 This invention relates to thermionic amplifiers  
 8 of the audion type,

1 and its object is to provide a structure by which certain desired  
2 characteristics of the amplifier may be secured at will and in an  
3 efficient manner. This object is accomplished by proportioning  
4 the geometrical and electrical relations of the various elements  
5 of the device in a manner more fully explained later in this  
6 specification.

7 In order that the novelty of this invention may be  
8 appreciated, and that those skilled in the art may be enabled  
9 to use this invention to best advantage, it is necessary that  
10 certain terms hereinafter used shall be defined. The following  
11 brief discussion is intended to explain the operation of the  
12 device and to define the terms to be employed.

13 The thermionic amplifier consists of a hot electron-  
14 emitting cathode, such as the so-called "Sahmelt" cathode, of a  
15 cool anode and of an auxiliary electrode called the grid, which  
16 is usually, though not always, located between the anode and the  
17 cathode. A battery is connected so as to force the electrons  
18 liberated at the cathode toward the anode, thus setting up a  
19 convection current carried by electrons in the evacuated space.  
20 In this specification since only the structure of the device it-  
21 self is under discussion, only the effects of changes in that  
22 structure are considered. Obviously a change in the battery will  
23 also change the characteristics of the circuit, but in a way which  
24 is already known in the art. Due to the presence of these  
25 electrons, a negative space charge is established between the  
26 anode and the cathode, whose effect is to limit the number of  
27 electrons which can leave the cathode, and consequently to limit  
28 also the current which can flow in the output circuit, by which  
29 is meant the circuit including the battery and the path of the space  
30 current. The object of the grid is to furnish a means for  
31 introducing a further negative charge into the space between  
32 the anode and the cathode, or for introducing into it a positive



1 charge which shall neutralize the effect of part of the space  
 2 charge due to the electrons. In the first case, the convection  
 3 current is decreased; in the second it is increased. In order  
 4 to force this charge to the grid, a source of electromotive force  
 5 is connected between grid and cathode, that is, between the input  
 6 terminals of the device. The effect of such an impressed electro-  
 7 motive force is therefore to alter the magnitude of the space  
 8 current in the amplifier by changing the distribution of space  
 9 charge between the electrodes, and moreover this is accomplished  
 10 without requiring that the impressed electromotive force shall  
 11 do more work than that involved in forcing the charge to the grid  
 12 against the counter voltage of the condenser formed by grid and  
 13 filament. Since in this operation the change in power consumed  
 14 in the output circuit may be much greater than that required in  
 15 charging the condenser, the device acts as an amplifier. This  
 16 variation in space current, due to an impressed electromotive  
 17 force, will hereafter be called the output current of the amplifier  
 18 and the variation in voltage, which appears in the output circuit  
 19 due to the impressed electromotive force, will be called the output  
 20 voltage. The reason for adopting these definitions is that in the  
 21 practical applications of the amplifier it is only these variations  
 22 in current or voltage which are utilized; in fact, a transformer is  
 23 ordinarily used to derive power from the output circuit, and  
 24 obviously the steady space current or the steady output voltage  
 25 have no effect on the secondary of that transformer and may be  
 26 ignored for practical purposes. Thus, the term voltage amplifica-  
 27 tion means here the ratio of the alternating voltage appearing in  
 28 the secondary of such a unity ratio transformer to the alternating  
 29 voltage impressed across the filament and grid, when the trans-  
 30 former primary is able to include the whole of the output circuit  
 31 connected to the amplifier. In simpler terms, it is the ratio of  
 32 the above defined output voltage to the impressed input voltage.

There will also be occasion to consider the ratio of output current to input voltage, the latter being taken as standard throughout. When this ratio is high, other things being the same, the amplifier will be said to be of the high current type, and vice versa. This latter ratio is, of course, not a pure number, but is of the nature of an admittance.

It has been found that amplifiers may be designed for given circuit conditions so that they will have whichever of the above mentioned characteristics is desired. That is, one may be designed to deliver to a receiving device a comparatively high voltage with a low current, or vice versa. The principles of operation which have been discovered which enable this result to be accomplished may be stated as follows.

In the first place it has been found that it is of advantage to locate the grid as near the cathode as possible whatever the desired voltage amplification or output current. In practice it has been found that when the two elements are separated only by a mere oxidizing coating the most efficient action is obtained. Unless there is a solid and continuous spacing element between the two it may be necessary of course to separate them a small distance to prevent actual contact between them due to forces set up during operation. By saying that the elements are placed as close together as possible it is meant that the distance between them is made as small as possible without introducing appreciable electrical or mechanical disturbances during operation.

Again, it has been found that, when the cathode and grid are placed as near to each other as possible, decreasing the distance from the anode to the cathode decreases the voltage amplifying power of the tube without at the same time reducing the variable current set up in the output circuit. That is, if we consider two tubes, one of which has the anode and cathode widely spaced while the other has them near together, the grid being very close to the



1 cathode in each case, the first tube when installed in a system  
2 of the usual kind tends to cause marked voltage amplification,  
3 while the latter is substituted for the former increases the vari-  
4 able current output and at the same time lowers the voltage ampli-  
5 fication.

6 A third principle of operation of the thermionic repeater  
7 which has been discovered may be stated as follows. To increase  
8 voltage amplification decrease the ratio of open space in the grid  
9 to conducting surface, and to decrease voltage amplification or to  
10 increase the variable output current increase this ratio.

11 The behavior of thermionic repeaters in another very  
12 important respect has been discovered. This may be stated as a  
13 fourth principle of operation as follows: Maximum efficiency is  
14 obtained when the impedance between the anode and cathode is equal  
15 to the total impedance of the variable current consumption circuit.  
16 ~~This total impedance includes the total line impedance and that of~~  
17 ~~the receiving or translating device or devices to which power is~~  
18 ~~being supplied.~~

19 It has been found that tubes may be constructed in such  
20 manner as to take advantage of any number or of all of the above  
21 mentioned principles with, of course, correspondingly increased  
22 efficiency and adaptability.

23 The invention will be better understood by reference to  
24 the following specification taken in connection with the accompany-  
25 ing drawings to which  
26

27 Fig. 1 represents the structure of an amplifying tube  
28 which is designed to give greater voltage amplification than those  
29 of the prior art; Fig. 2 is a plan view of the amplifier of Fig. 1  
30 arranged to exhibit the geometrical configuration; Fig. 3 is a  
31 view of a tube structure designed to give a large output current  
32 with low or negative voltage amplification; Fig. 4 is a plan view  
33 of the structure of Fig. 3; Figs. 5 and 6 are views corresponding to

to Figs. 3 and 4 respectively of a modified structure of the new type of amplifier; Fig. 7 is a circuit diagram showing an amplifying system making use of an amplifier of the type shown in Fig. 1; Figs. 8, 9 and 10 are circuit diagrams showing several forms of circuit making use of an amplifier of the kind shown in Fig. 3. In these figures, like numerals represent corresponding parts.

Referring to Figs. 1 and 2, 1 represents the grid element, 2 the cathode or filament and 3 the anode or plate. The plate is placed a considerable distance from the cathode, and the grid is placed very close to the cathode and may be separated therefrom only by a thin insulating film as, for example, an oxidizing coating on one or the other of these elements. Further, the grid is made to have a fine mesh and thus to obstruct greatly the view of the plate as seen from the cathode.

Figs. 3 and 4 are two views of a thermionic amplifier of the high current type. In these structures, in conformity with the above mentioned principles, the distance from plate 3a to cathode 2a is made very small, and the grid is placed as close as possible to the cathode. Further, the grid is made to have a coarse mesh, or is constructed to have a large ratio of open space to conducting surface, as is required by the conditions above set forth for this type of amplifier.

Figs. 5 and 6 show another modification of the high current type of amplifier. The input electrode or grid is in the form of a wire 1b, bent back at its middle. In effect, therefore, the input electrode consists of two wires joined together. The filament 2b is wound about the input electrode and is insulated therefrom by a tube of insulating material 4, an arrangement which is not the invention of this applicant, but is described and claimed in patent 1,169,244 of Jan. 25, 1918 to Alexander McLean Nicolson. The output electrode or anode consists of two plates 3b, 3c arranged upon opposite sides of the filament and close to it. It will be noted that the input electrode is not located between the filament and plate, such not being necessary in this high current type of tube.



Fig. 7 is a diagram of an amplifying system in which a tube V of the type shown in Fig. 1 is employed. The tube has the usual input circuit 4, and output circuit 5, 5. The exact arrangement of input and output circuits is that shown in patent 1,126,142 to this applicant. In this patent there is shown and claimed a combination of the systems of the types shown in Figs. 7 and 8 respectively of this application, such combination having marked advantages for certain purposes specified in said patent. The purpose of the present application is to specifically describe and claim these types of system employing novel thermionic amplifiers, these being capable of more general use than that disclosed and claimed in the above mentioned patent.

A source of potential 7 may be inserted in the input circuit to bring the grid to a desired initial or working potential. No transformer need be used, the incoming line being directly connected to the input electrodes, and the outgoing line, to the output electrodes. A high resistance element 6 may be connected across the input circuit as shown. A coil 8 of large inductance provides a path for direct current for the tube V, such current being supplied by a source B. The coil 8 will not conduct an appreciable amount of the variable current in the output circuit owing to its high impedance to such current. The condenser 9 is inserted in the line to prevent flow of direct current from the source B through the receiving device 10 if the latter does not itself prevent such flow.

The receiving device 10 may be one which operates most efficiently upon high variable voltage and low current. In accordance with the principles discussed above, the grid and cathode are placed very close together while the plate 5 is widely separated from the cathode, the distance between the two being that necessary to give the desired current and voltage output characteristics. It is usually necessary, however for efficient operation to consider first the impedance characteristics of the tube between filament and plate and the receiving device and line, in accordance with the fourth principle of operation stated above. The receiving device

10 is one of high impedance and accordingly the impedance of the tube between filament and plate is made high, the two impedances being made as nearly the same as possible consistent with other possible conflicting requirements. They should at least be of the same order of magnitude, for example one being 100,000 ohms and the other 25,000 ohms. The receiving device 10 may be a second amplifying tube or similar device.

Fig. 8 is a diagram of a system the same as that of Fig. 7 except that a receiving device having relatively low impedance or operating efficiently upon relatively large variable current and low voltage, or both, is present. Accordingly, the anode 3a and cathode 2a of the tube are placed relatively near together, the grid 1a being as before very close to the cathode. The impedance of the amplifier between filament and plate is made the same as that of the receiving device 11, or as nearly the same as other operating conditions will permit, and at least of the same order of magnitude.

It has been found that in accordance with this invention an amplifier of the type shown in Fig. 8 may be constructed which will develop amplified energy at a voltage one third of the voltage of the input energy and having an anode-to-cathode impedance as low as 500 ohms. Such an amplifier can, then, be worked efficiently into a receiving device or line having this relatively low impedance and the efficiency with a receiving device of even much lower impedance would be relatively high much higher than that heretofore attainable.

Fig. 9 shows the same circuit as Fig. 7 except that a high resistance element 13 is substituted for the coil 8, this resistance being so large that the variable current through it is negligible. The high-current, low-voltage-amplification type of amplifier is here shown, a tube impedance of the same order as that of the telephone receiver 15 being thus obtained.

In Fig. 10 is shown a system similar to that of Fig. 8 except that input and output transformers, 14 and 16 respectively are employed. Except for the tube structure systems of this kind



have been in use for some time. The elements of the tube are here spaced and the grid constructed in accordance with the principles herein disclosed, the tube being of the type illustrated in Fig. 5.

The impedance of the primary winding 17 of the transformer 18 is low and accordingly the cathode-to-anode impedance is made of the same order, the ratio of the number of turns of coil 18 to that of coil 17 being the same as the ratio of the impedance of receiving device 15 to that of the primary winding 18. A direct current source B' is here shown as the source of space current, it being understood of course, that the type of source used is immaterial. An impedance coil 22 may be inserted in series with the source B' to reduce the current variations set up by the commutator of the machine. These variations may be of frequency quite different than that of the variable current set up by the tube V', so that the coil 22 may discriminate between them. If the impedance of the primary coil 17 is high, as might be the case if it were desired to use a step down transformer, the cathode-to-anode impedance of the tube V' would of course be increased the desired amount.

By thermionic repeater is meant a repeater depending for its operation upon current discharge from a heated cathode. It is obvious, however, that the invention might be applied to a discharge device in which other means is employed for liberating electrons from the cathode. In its broadest aspect the invention is not limited to the particular structure herein illustrated, but may be found useful in modified form or types of discharge tubes and in connection with a variety of circuit arrangements.

*Be A*  
 This application is a continuation of application  
 Serial No. 22,207, filed May 22, 1924.

## WHAT IS CLAIMED IS:

1. ✓ A thermionic discharge tube having a cathode, an anode and a controlling electrode, said anode being located in such close proximity to the cathode that the tube operates to produce energy amplification without substantial voltage amplification.
2. ✓ A thermionic discharge tube having a cathode, an anode, and a controlling electrode, said controlling electrode and said anode being located in such close proximity to the cathode that the tube operates to produce energy amplification without substantial voltage amplification.
3. ✓ A thermionic discharge tube having a cathode, an anode and a controlling electrode, said anode being located in such close proximity to the cathode as to keep the internal impedance of the tube sufficiently low to permit of energy amplification without substantial voltage amplification.
4. ✓ The combination with a thermionic discharge tube having a cathode, an anode, and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit,



and translating means for utilizing the variable current of said output circuit, said cathode being located so close to both said anode and said impedance varying element, that, for the impedances and voltages employed outside the tube, the tube operates to amplify the energy in said input circuit without amplifying the voltage.

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5. The combination with a thermionic discharge tube having an anode, a cathode, and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode being placed as close as possible to the impedance varying element so that, for the impedances and voltages employed outside the tube, the tube operates to amplify the energy in said input circuit without amplifying the voltage.

6. The combination with a thermionic discharge tube having a cathode, an anode and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said impedance varying

element being in immediate proximity to the cathode but out of electrical contact therewith, and closer to the cathode than to the anode, so that for the impedances and voltages employed outside the tube, the tube operates to amplify the energy in said input circuit without amplifying the voltage.

7. The combination with a thermionic discharge device having a cathode, an anode and a control element, of an input circuit therefor, and an outgoing circuit having impedance and connected to said anode and cathode, said cathode, anode and control element being so spaced that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit.

8. The combination with a thermionic discharge device, having an anode, a cathode and a control element, of an input circuit therefor, and an outgoing circuit having impedance and connected to said anode and cathode, said cathode, anode and control element being so spaced that the impedance of said discharge device between said anode and said cathode is approximately the same as that of said outgoing circuit.

9. The combination with a thermionic discharge device having a cathode, an anode, and a control element, of an input circuit connected to said cathode and said control element, an outgoing circuit



having impedance and connected to said anode and cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said control element but out of electrical contact therewith, and said anode being so spaced from said cathode and control element that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit.

10. The combination with a thermionic discharge device having a cathode, an anode, and a grid, of an input circuit connected to said cathode and said grid, an outgoing circuit having impedance and connected to said anode and cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said grid but out of electrical contact therewith, and said anode being so spaced from said cathode and grid and the said grid being of such shape such that the impedance of said discharge device between said anode and said cathode is of the same order as that of said outgoing circuit.

11. The combination with a thermionic discharge device having a cathode, an anode and a control element, of an input circuit connected to said,

cathode and said control element, an outgoing circuit having impedance and connected to said anode and said cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode being placed in immediate proximity to said control element but out of electrical contact therewith, and said anode being so spaced from said cathode and control element that the impedance of said discharge device between said anode and said cathode is approximately the same as that of said outgoing circuit.

13. The combination with a thermionic discharge device having a cathode, an anode, and a control element, of an input circuit connected to said cathode and said control element, an outgoing circuit having impedance and connected to said anode and said cathode, a source of electromotive force in said outgoing circuit, and means for impressing a varying electromotive force upon said input circuit, said cathode, anode and control element being so placed that the impedance of that portion of the input circuit which is within the discharge device is made as small as possible without introducing disturbing mechanical or electrical variations under working conditions, and the impedance of that part of the outgoing circuit which is within the discharge device is made of the same order as that of the effective impedance of that part of the outgoing circuit which is external to the discharge device.





13. The combination with a thermionic discharge device having a cathode, an anode, and an impedance varying element, of an input circuit and an output circuit therefor, an impedance element in said output circuit, means for producing a variable electromotive force in said input circuit, and a source of electromotive force in said output circuit, said cathode being as near as possible to said impedance varying element and said anode being relatively widely spaced from said cathode, whereby the variable voltage across said anode and cathode in said output circuit is much greater than that in said input circuit.

14. The combination with a thermionic discharge device having a cathode, an anode, and an impedance varying element, of an input circuit and an output circuit therefor, an impedance element in said output circuit, means for producing a variable electromotive force in said input circuit, and a source of electromotive force in said output circuit, said cathode being in immediate proximity to said impedance varying element and said anode being relatively widely spaced from said cathode and said impedance varying element being in the form of a discontinuous conductive structure, the ratio of conductive surface to open space in said impedance varying element being high, whereby the variable voltage across said anode and cathode in said output circuit is much greater than that in said input circuit.

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13. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit.

14. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit non-magnetically connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit.

15. The combination with a thermionic discharge device having an anode, a cathode, and an impedance varying element, of an input circuit connected to said impedance varying element, a source of variable electromotive force in said input circuit, a source of electromotive force connected to said anode and cathode, and a work circuit connected to said anode and cathode, the impedance of said discharge device between said cathode and anode being of the same order as that of said work circuit, the variable power delivered to said work circuit being much greater than that supplied by said input circuit, while the variable voltage delivered is correspondingly less than in said input circuit.

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IN WITNESS WHEREOF, I hereunto subscribe my name

this 29th day of July A.D., 1915.

Harold D. F. Arnold

O A T H

State of New York } ss.  
County of New York }

HAROLD D. F. ARNOLD, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of Maplewood, in the County of Essex and State of New Jersey, and that he verily believes himself to be the original, first, and sole inventor of the improvement in THERMIONIC AMPLIFIERS, described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the application of which this is a continuation, or in public use or on sale in the United States for more than two years prior to the application of which this is a continuation; that the said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to the application of which this is a continuation; and that no application for patent on said improvement has been filed by him or his legal representatives or assigns in any country foreign to the United States.

Harold D. F. Arnold

Sworn to and subscribed before me

this 29th day of July 1915.

John P. Hunter  
Notary Public

880

Div. 16 Room 112  
 Address only  
 The Commissioner of Patents,  
 Washington, D. C.,  
 and not any other office.

ABS.

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Paper No. 5

All communications respecting this  
 application should give the serial number,  
 date of filing, title of invention, and  
 name of the applicant.

DEPARTMENT OF THE INTERIOR  
 UNITED STATES PATENT OFFICE

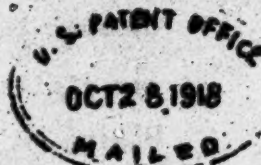
WASHINGTON

Oct. 25, 1918.

John G. Roberts, Esq.,

300 Broadway,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold De P. Arnold, Ser. No. 847,422, filed July 30, 1918.

Actions.

James S. Newton  
 Commissioner of Patents.

This application has been examined.

Applicant's residence as given in the petition and oath is Maplewood, New Jersey, while in the preamble to the specification it is given as East Orange, New Jersey. Uniformity is required.

Page 6, line 4, "7, 8 and 9" should be 8, 9 and 10.

Claim 17, lines 12 and 13, the expression "while the variable voltage delivered is correspondingly less" is not clear as the claim does not indicate with what the voltage delivered is compared.

Claims 1, 2, 3, 4, 5, 6 and 12 are objectionable in view of the negative limitation beginning with "without". These claims differ only in that negative limitation from the usual amplifying audion, such as is shown in Fig. 43 on page 65 of The Wireless Telephone, by H. Cernsback, 2nd Edition, published by the Modern Publishing Co., 233 Fulton Street, New York City, 1911.

Noted Sept 4-1919  
 J. H. S. [illegible]  
 3-10-19  
 212.57



Ser.No. 247,422.

#2.

At present there is not a clear line of division between this application and application No. 235,043. See claims 7 to 12, 15 and 16 of this application and claims 12, 13, 14 and 15 of application No. 235,043.

Claims 7 to 12, 15 and 16 are rejected on patent No.1,129,959, COLPITTS, Mar. 2, 1915 (179-171). The group of audions are arranged so that their internal impedance is of the same order as the impedance of the output circuit.

Claims 13 and 14 are specific to species of applicant's invention different from that to which claims 1, 2, 3 are directed. Division is accordingly required.

As the subject-matter of this application has been pending for more than four years, a prompt reply is requested.

*A. D. B. [Signature]*  
Examiner, Division 16.

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U.S. PATENT OFFICE

Case 882

PAPER NO. 4  
AMENDMENT A

UNITED STATES PATENT OFFICE.

Division.....Room.....

19

In re application of

Harold DeForest Arnold

Subject.

Audions

Serial No. 247,422

Filed July 30, 1918

PATENT OFFICE  
MAY 3 1919

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

Please amend the above entitled application as follows:

- ✓ Page 1, line 3, change "East Orange" to "Maplewood--."
- ✓ Insert the following at line 25, page 5:

The object of this invention is to provide an audion, or an equivalent device, which will amplify the variable energy supplied thereto without at the same time causing a large voltage amplification, as in systems of this type heretofore used. Or, differently stated:

To provide an audion, or equivalent device, which will cause the amplified energy which appears in the output circuit to take the form of large variable current, rather than smaller variable current with large voltage amplification.



(Serial No. 247,122)

Another object is to provide an audion, or equivalent, system by which a proper impedance ratio is obtained between the impedance of that portion of the output circuit which is without the audion and that of the remaining portion of the external circuit, whereby a greatly increased efficiency is obtained.

A further object of the invention is to provide an audion, or equivalent device, which will operate with increased efficiency when the translating device to which the amplified energy is supplied in the output circuit of the device is one which operates best upon maximum variable current, as distinguished from one which operates best upon maximum variable voltage.

Another object of the invention is to provide an audion, or equivalent device, which will operate efficiently with a current operated translating device without the use of a voltage transformer between the audion and the translating device.

Viewed broadly, the invention provides for an increase of the efficiency of an audion, or equivalent device, by novel spacing of the electrodes and the current

(Serial No. 247,422)

control element, and also an increase of efficiency, when used with a current operated translating device, by obtaining the proper ratio of the conductive surface to open space in the grid or current control element.

Other and more specific objects of invention will be apparent from the appended claims. *W*

✓ Page 6, line 4, change "7, 8 and 9" to --8, 9 and 10 respectively.--

✓ Cancel lines 31 and 32, page 9.

✓ Cancel claim 5 and substitute therefor the following:

*5.* The combination with a thermionic discharge device having an anode, a cathode and a grid, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode being placed so close to said grid and said grid being of such fine mesh that, for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without

*amplifying the voltage.*



(Serial No. 247,422)

*copied*out amplifying the voltage. 14.

✓ Cancel claims 13 and 14, renumber the remaining claims as 13, 14 and 15.

✓ Claim 15, former claim 17, cancel the period at the end of the claim and add --then in said input circuit.--

✓ Add the following claims:

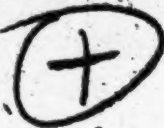
**16. Means for amplifying energy** without substantial voltage amplification, comprising a vacuum discharge tube having an input and an output circuit, a source of variable energy to be amplified connected in said input circuit, and a translating device to which the amplified energy is delivered connected in said output circuit.

**17. Means for amplifying energy** without substantial voltage amplification comprising an electric discharge device having an anode, a cathode and a current control element, an input circuit and an output circuit for said device, a source of variable energy to be amplified connected in said input circuit, and a translating device to which the amplified energy is delivered connected in said output circuit.

Serial No. 247,422

18. Means for amplifying energy without substantial voltage amplification comprising an electric discharge device having an input circuit and an output circuit, a translating device to which the amplified energy is delivered connected in said output circuit, the impedance of that portion of said output circuit which is within said discharge device being of the same order of magnitude as the impedance of said translating device.

19. The combination with an electronic discharge device having an anode, a cathode and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said impedance varying element being in the form of a discontinuous conductive surface, the ratio of conductive surface to open space being so low that, for the impedances and voltages employed outside said device, the device operates to amplify <sup>variable</sup> the ~~variable~~ energy in said input circuit without amplifying the voltage.





20. The combination with an electronic discharge device having a cathode, an anode and a grid, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said anode being so close to said cathode and said grid being of such coarse mesh that, for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

21. The combination with a thermionic discharge device having a cathode, an anode and a grid, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode being located in immediate proximity to said grid but out of contact therewith, and the grid being of

such source mesh, that for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

22. The combination with an electronic discharge device having a cathode, an anode and a grid, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of electromotive force in said output circuit, and translating means for utilizing the variable current of said output circuit, said cathode being placed in immediate proximity to said grid, but out of contact therewith, said anode being so close to said cathode, that for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

23. The combination with an electronic discharge device having a cathode, an anode and an impedance varying element, of an input circuit and an output circuit therefor, means for producing a variable electromotive force in said input circuit, a source of



electromotive force in said output circuit and translating means for utilizing the variable current of said output circuit, said cathode, anode and impedance varying element being so spaced that for the impedances and voltages employed outside said device, the device operates to amplify the variable energy in said input circuit without amplifying the voltage.

24. Means for amplifying energy without substantial voltage amplification comprising an electric discharge device having an anode, a cathode and a current control element, an input circuit for said device, a source of variable energy to be amplified connected in said input circuit, and a work circuit to which the amplified energy is delivered non-magnetically connected in said output circuit.

25. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode in immediate proximity to said cathode but out of electrical contact therewith and closer to said cathode than to said output electrode.

(Serial No. 247,422)

26. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode as close as possible to said cathode without contacting therewith and closer to said cathode than to said output electrode.

### REMARKS

Claims 13 and 14 have been cancelled in response to the requirement for division and with no intention of abandoning the subject matter.

Claims 16 to 25, inclusive, are added to more completely protect the invention.

Claims 25 and 26 are allowed claims 1 and 2, respectively, of applicant's pending application, Serial No. 841,567. Applicant desires it to be understood that this application is a continuation of application, Serial No. 841,567 and also of the application upon which issued patent No. 1,129,942 to this applicant.

Claim 15, former claim 17, has been amended to overcome the objection noted by the Examiner.

Reconsideration of the objection to claims 1, 2, 3, 4, 5, 6 and 12 is respectfully requested. Claim 1, for example, does not read upon the system shown in "The Wireless Telephone", since it does not disclose an anode located in such close proximity to the cathode that the tube operates to produce energy amplification without substantial voltage ampli-



(Serial No. 347,432)

fication. This is a structural limitation and is clear and definite. It is understood that there can be no objection to a negative limitation which does not introduce indefiniteness or ambiguity into the claim. It is therefore submitted that applicant is entitled to these claims.

The Examiner is asked to reconsider the question of a line of division between this application and application No. 235,043. The claims of this application which the Examiner cites as covering the same matter as claims of the application No. 235,043 contain limitations which would prevent the claims from being made in the latter application, see for example, claims 9, 10, 11 and 12 and former claim 16. It is questionable also whether claims 7, 8, 9 and 15 could properly be made in the application 235,043, as the latter application does not disclose the spacing of the electrodes for the purpose indicated. If, however, the Examiner is still of the opinion that there is not a line of division between the two applications, no objection will be made to establishing a proper line.

An affidavit under Rule 75 is filed herewith to overcome the effect of the Colpitts patent No. 1,229,959.

Respectfully,

HAROLD DEFOREST ARNOLD,

By J. S. Roberts  
Attorney

920 Broadway,

New York,

May 1<sup>st</sup> 1919.

CAS:V  
Enclosure

MAIL MAY 1919  
U.S. PATENT OFFICE

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#4

UNITED STATES PATENT OFFICE

State of New York )  
County of New York ) ss.

PATENT  
MAY 3 1919

Harold DeForest Arnold, whose application for improvements in Audions, Serial No. 247,422, was filed in the United States Patent Office on or about July 30, 1918, deposes and says:

That prior to April 6, 1914, he made the invention disclosed in the attached sketch marked "Arnold Case 8-A Exhibit 1"; that prior to April 6, 1914, he disclosed said invention to Mr. P. H. Pierce and others; that said sketch is an accurate copy made by tracing of an ink sketch made prior to April 6, 1914, in a research note book to record the result of work done by said Pierce under his, Arnold's direction; that during said work, said invention was operated successfully; that the internal impedance between the plate and filament of the left-hand vacuum tube in the sketch of said exhibit was of the order of magnitude of the joint impedance of the element marked "100,000 ohms" and the internal input circuit impedance of the right-hand tube of the sketch of said exhibit; that he does not know and does not believe that the invention has been in public use or on sale in this country, or patented or described in a printed publication in this or any foreign country for more than two years prior to his application, and that he has never abandoned the invention.

*Harold DeForest Arnold*

Sworn to and subscribed before me this

1st day of May, 1919.

*Walter S. Tanton*  
Notary Public.

EVO:IM

APPROVED:  
June 24 1919  
W. S. Tanton  
Notary Public



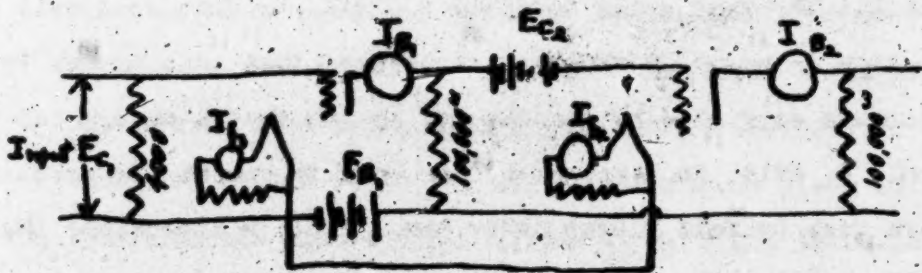
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Arnold Case S.A. Exhibit 1.

DEPARTMENT OF COMMERCE  
UNITED STATES PATENT OFFICE

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records  
of this office of the File Wrapper and Contents, in the  
matter of the

Letters Patent of

Harold D. Arnold, Assignor to  
Western Electric Company, Incorporated,

Number 1,403,475.

Granted January 17, 1922,

for

Improvement in Vacuum-Tube Circuits.

IN TESTIMONY WHEREOF I have hereunto set my  
hand and caused the seal of the Patent Office to be  
affixed, at the City of Washington, this twenty-third  
day of October in the year of our Lord, one  
thousand nine hundred and twenty-nine and of the  
Independence of the United States of America the one  
hundred and fifty-fourth.

ATTEST:

*J. E. Wilson*  
Chief of Division

*Thomas E. Robertson*  
Commissioner of Patents



~~SECRET - Dr. Donaldson - 1915~~

1 This invention relates to vacuum tube circuits  
2 and particularly circuits of the type in which a plurality  
3 of vacuum tubes are arranged in tandem.

4 The object of the invention is to provide an improved  
5 circuit connection between vacuum tubes whereby fluctua-  
6 tions of current in the output circuit of one vacuum tube  
7 may be impressed on the input circuit of another vacuum tube.

8 In accordance with this invention, the output  
9 circuit of a vacuum tube is provided with a path for direct  
10 current comprising an impedance, preferably a resistance,  
11 and the input circuit of the succeeding tube is connected  
12 across a portion of the direct current path containing said  
13 impedance. A condenser is placed between the direct current  
14 circuit and the second tube to prevent the flow of direct  
15 current, and a direct connection is also made between the  
16 input electrodes of the second tube so that a normal poten-  
17 tial difference may be applied therebetween. (3)

18 *Insert C* The invention further resides in the specific de-  
19 tails of the circuit hereinafter to be described, and shown  
20 in the accompanying drawing, in which the figure represents,  
21 schematically, a circuit embodying the invention.

22 The subject matter of this application is divided  
23 out of application serial No. 48,873, filed September 3,  
24 1915, for ~~radio~~ communication.

25 Reference numerals are used in this application  
26 corresponding to those used in the application above referred

27 to. *to. 2 (3)*  
28 Coil 12, which may be connected to any suitable  
29 circuit upon which electric impulses may be impressed is  
30 inductively connected with the tuned circuit comprising coil  
31 10 and condenser 15. Across the terminals of condenser 20,

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1 is connected the input circuit of a detecting device which com-  
2 prises vacuum tube 21, condenser 22 and resistance 23. For the  
3 detection of modulated high frequency signals the purpose of  
4 the combination of the condenser and high resistance in connection  
5 with vacuum tube 21 is as follows - when a positive charge, for  
6 example, is forced upon the grid 9 of element 21, this charge is  
7 neutralized by electrons from the filament 8. Then, when a neg-  
8 ative charge is forced upon the grid by the incoming wave, this  
9 charge adds to that already present and produces a still larger  
10 negative charge upon the grid, since the negative charge cannot  
11 be neutralized by the electron stream. The condenser, there-  
12 fore, aids in decreasing the average current in the output circuit.  
13 The grid must, however, be conductively connected to the incoming  
14 circuit, otherwise the accumulated negative charge would remain  
15 and prevent further operation. To provide for this, a high resis-  
16 tance leakage path 23 is shunted around the condenser 22 to allow  
17 a leak, slow compared with the period of high frequency currents,  
18 but still rapid enough to permit considerable leakage in a time  
19 comparable with a period of telephonic waves.

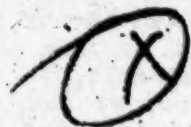
20 The output circuit of this vacuum tube is supplied with  
21 current by battery 27 coming through choke coil 28 and resistance  
22 25, to the anode 10 condenser 24 serving as a high frequency  
23 shunt and condenser 26 to limit the direct current to the detector  
24 circuit. The amplifier tube 31 has a battery 30 in series with  
25 its grid with resistance 29 across its input circuit. The output  
26 circuit of amplifier 31 comprises a battery 34 and choke coil 35,  
27 both shunted by condenser 33, and a coil 32. Coil 32 is induct-  
28 ively associated with coil 36 which may be connected to any suit-  
29 able circuit for the utilization of the amplified currents.

30 While a circuit has been shown which is especially  
31 adapted for the detection and amplification of modulated high

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1 frequency currents, it is obvious that the features of the  
2 circuit relating to the object of this invention are adapted  
3 for use in repeating electrical impulses of other forms.



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4. <sup>l.c.</sup> WHAT IS CLAIMED IS:

1. In combination, a vacuum tube having output electrodes, a path comprising a source of direct current and an impedance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected across a portion of said first path containing said impedance, and means for applying a steady difference of potential between said input electrodes.

2. In combination, a vacuum tube having output electrodes, a path comprising a source of direct current and a resistance connected to said electrodes, and a second path comprising a condenser and the input electrodes of a second vacuum tube connected across a portion of said first path containing said resistance, and means for applying a steady difference of potential between said input electrodes.

3. In combination, a vacuum tube having output electrodes, a path comprising a source of direct current and an impedance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected across a portion of said first path containing said impedance, and a conductive path between the input electrodes of said second tube.

4. In combination, a vacuum tube having output electrodes, a path comprising a source of direct current and a resistance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected across a portion of said first path containing said resistance, and a conductive path between the input electrodes of said second tube.



5. In combination, a vacuum tube having output electrodes, a path comprising a source of direct current and a resistance connected to said electrodes, a second path comprising a condenser and the input electrodes of a second vacuum tube connected across that portion of said first path comprising said resistance and said source of direct potential, and a conductive path between the input electrodes of said vacuum tube.

6. In combination, two vacuum tubes, a circuit connecting the output electrodes of one of said tubes to the input electrodes of the other of said tubes, said circuit comprising a series condenser and a shunt impedance at each side of said condenser.

7. In combination, two vacuum tubes, a circuit connecting the output electrodes of one of said tubes to the input electrodes of the other of said tubes, said circuit comprising a series condenser and a shunt path at each side of said condenser, each of said paths comprising a resistance.

8. In combination a circuit comprising a resistance and means for producing potential variations across said resistance, a vacuum tube having input electrodes, and connections for impressing said variations on said electrodes, said connections comprising a series condenser.

9. In combination, a circuit comprising a resistance, a source of direct current and means for producing variations in said current, a vacuum tube having input electrodes, and connections for impressing said variations on said electrodes, said connections comprising a series condenser.

423-17

condenser.

10. In combination, a circuit comprising a resistance and means for producing potential variations across said resistance, a vacuum tube having input electrodes, connections for impressing said variations on said electrodes, said connections comprising a series condenser, and a resistance shunt for said input electrodes.

11. In combination, a circuit for the reception of modulated high frequency currents, a vacuum tube for detecting and amplifying said currents, said vacuum tube having an impedance in its output circuit, and a circuit connected substantially in parallel with said impedance for impressing variations in the output circuit on another amplifier, said second circuit comprising a series condenser.

12. In combination, a circuit for the reception of modulated high frequency currents, a vacuum tube for detecting and amplifying said currents, said vacuum tube having an impedance in its output circuit, a circuit connected substantially in parallel with said impedance for impressing variations in the output circuit on another amplifier, said second circuit comprising a series condenser, and a shunt conductance.

13. A detector and amplifier of high frequency currents having in its output circuit a source of direct current, an inductance and a resistance in series, an amplifier having its input circuit in parallel with said series circuit, and a path of low impedance having one terminal in common with said circuits, and its other terminal connected between said resistance and said inductance.

423259-8



*14.* 14. A detector and amplifier of high frequency currents having in its output circuit a source of current and an inductance, a translating device having an input circuit connected in parallel to a portion of said output circuit containing said inductance, and a path of low impedance to high frequency current connected in parallel to a portion of said output circuit containing said inductance.

*inserted*

*Cl. 15*

MAW:MM

*l.c.*  
 IN WITNESS WHEREOF, I hereunto subscribe my  
 name, this 5<sup>th</sup> day of November, A. D. 1920, 1920.

Harold D. Arnold

State of New York }  
 County of New York } ss.

HAROLD DE FOREST ARNOLD, the above-named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of Maplewood, in the County of Essex and State of New Jersey, and that he verily believes himself to be the original, first and sole inventor of the improvement in VACUUM TUBE AMPLIFIERS, described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the application of which this is a division, or in public use or on sale in the United States for more than two years prior to the application of which this is a division; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to the application of which this is a division; that no application for patent on said improvement has been filed by him or his legal representatives or assigns in any country foreign to the United States, prior to the filing date of the application of which this is a division; that the subject matter claimed herein was a part of his invention disclosed in the application of which this is a division, was invented before he filed said application and has not been abandoned.

1123259-10



Harold O. Arnold

Sworn to and subscribed before me

this 5<sup>th</sup> day of November, 1920Jacob F. Gilchrist  
NOTARY PUBLIC  
New York Co. Clerk's No. 484  
Comm. Expires March 31, 1922

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Feb. 2, 1921

Mr. John G. Roberts,

445 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of  
Harold D. Arnold, Ser. #123,229, filed Nov. 11, 1920.

Vacuum Tube Circuits.

*R. F. Whitehead*  
Commissioner of Patents

This application has been examined.

Claims 3, 4, 5, and 8 to 12 are rejected as involving no invention over

ARNOLD, 1,114,845, Oct. 27, 1914, 179-171.

It should be noted that in Fig. 5 of the patent, the input terminals of a second amplifier might well, and without invention, be substituted for the primary coil of transformer 6. Additional stages of amplification may obviously be inserted whenever desired.

All other claims appear allowable.

Inasmuch as this application has an effective filing date of five years or more, it comes within Commissioner's Order 2210, 216 O. G. 1 respecting delayed applications, and applicant is, therefore, strongly urged to present an early response, placing this case in condition for final action before the examiner.

*[Signature]*

EXR., Div. 16.

420 259-12

B.





Case.....161.....

PAPER NO. 3  
AMOUNT NUM. 1

UNITED STATES PATENT OFFICE.

Division 14 Room 112

26

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 425,289

VACUUM TUBE CIRCUITS.

Filed November 11, 1920

THE COMMISSIONER OF PATENTS,  
Washington, D. C.



Sir:

In response to the Office Action of February 2, 1921, please amend the above entitled application as follows:

add the following claim:

15. In combination, a vacuum tube having output electrodes, a path for direct current comprising said output electrodes, a source of current and an impedance, and a path for alternating currents comprising a condenser and a work circuit, said second path being in parallel to a portion of said first path containing said impedance.

REMARKS

Reconsideration of the rejection of claims 3, 4, 5 and 6 to 12 on Arnold patent No. 1,114,845 is respectfully requested. It is believed that invention was involved at the applicant's original filing date in substituting a vacuum tube amplifier for the transformer 5 shown in applicant's prior patent. A vacuum tube when employed as an amplifier draws substantially no current from its input circuit, being operated

42-247-13

FORM NO. 15  
COMMUNICATION TO  
PATENT OFFICE  
2-10-20

(Serial No. 425,859)

-2-

substantially wholly by the static effect of changes in input potential. It was not obvious that the high impedance, potential operated vacuum tube would operate satisfactorily if substituted for the low impedance, current actuated work circuit of the reference patent. This is borne out by the fact that no prior inventor had hit upon this arrangement, although the three electrode vacuum tube had been known for many years. The arrangements which had been suggested by prior inventors for connecting tubes in tandem are not so satisfactory for ordinary repeater work as that claimed in this application. Prior schemes are shown in the following patents: Von Lieben, Reiss and Strauss, French Addition 15,736 published June 17, 1911. This patent shows a transformer connection between tubes. A transformer is an expensive piece of apparatus, and furthermore is not equally efficient at all frequencies. DeForest patent 1,177,846, April 4, 1916, originally filed June 24, 1913, shows a metallic connection between tubes with a shunt inductance for the space current, but shows no means for controlling the steady potential for the grid of the second tube. Langmuir patent 1,332,459, October 22, 1916, filed October 29, 1913, in Fig. 1, shows an arrangement in which a resistance is employed in the location of DeForest's shunt inductance, and battery is added for controlling the grid potential. This battery, however, is conductively connected to the battery supplying space current to the first tube, and as a result it is more difficult than applicant's circuit to maintain in proper adjustment. This circuit has been found to be of practical utility in laboratory instruments. In applicant's circuit the grid potential battery is separated



from the direct current circuit of the preceding tube by a condenser which can very inexpensively be made large enough that it will not appreciably impede the transmission of telephone currents. Another example of a circuit for connecting tubes in tandem is Pierce patent 1,112,655, October 6, 1914, filed August 5, 1913. The circuit of this patent appears to depend for its operation on the presence of gas in the second tube and would not be operative if pure electron discharge tubes were used.

For the above reasons it seems clear that the arrangement set forth in the rejected claims is patentable over the disclosure of the applicant's prior patent. Claims 3, 4, 5, 10 and 12 also call for a conductive shunt between the input electrodes of the second tube. The Examiner has cited no reference showing this feature.

Furthermore, in view of ex parte Mullen and Mullen 50 C.C. 407, it is believed that applicant is entitled in this application to make claims, regardless of whether they involve patentable novelty over this feature of applicant's prior patent. The claim in the prior patent relates to the use of a resistance in the output circuit of the vacuum tube for preventing blue haze. The arrangement shown in Fig. 3 for separating the work circuit from the direct current by means of a condenser is not claimed and it is believed that there is no presumption of dedication of the public on account of the failure to claim it in the patent. This is believed to come clearly within the third class of cases referred to in

423259-10

(Serial No. 423,259)

-4-

29

ex parte Hallen. The claims now being made in this application are for an invention which is independent of that claimed in the patent and the Office no doubt would have required division between said claims and the claim for means for preventing blue haze, if claims to both features had been made in the prior application. Accordingly new claim 15 has been added to cover the arrangement shown in Fig. 3 of patent No. 1,114,945 and allowance of this claim is respectfully requested. Regardless of the action that may be taken on claim 15, applicant for the reasons given above is of the opinion that claims 3, 4, 5 and 8 to 12 inclusive are clearly patentable over the disclosure in the prior patent.

Favorable consideration and allowance of the claims is respectfully requested.

Respectfully,

HAROLD D. ARNOLD

By

*W. A. Beatty*  
Attorney.

443 West Street

New York, *April* 7 1921.

HAN:CH

60/15



909



SUPPLEMENTAL OATH

JUN 9 1921

State of New York     }  
County of New York   } ss.

HAROLD D. ARNOLD, whose application for Letters Patent for an improvement in Vacuum Tube Circuits, Serial No. 425,250, was filed in the United States Patent Office on or about the 11th day of November, 1920, being duly sworn, deposes and says that the subject matter of claim 15 of the amendment filed April 2, 1921 was part of his invention, was invented before he filed his original application, of which the above identified application is a division, for such invention, was not known or used before his invention, was not patented or described in a printed publication in any country more than two years before his application, was not patented in a foreign country on an application filed by his legal representatives or assigns more than twelve months before his application, was not in public use or on sale in this country for more than two years before the date of his application, and has not been abandoned.

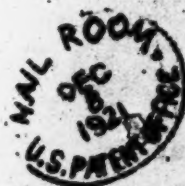
*Harold D. Arnold*.....

Sworn to and subscribed before me this  
day of June, 1921.

*[Signature]*  
Notary Public

NAWICK

NOTARY PUBLIC, Commission  
Expires August 1st, 1922  
Certificate No. 1176  
State of New York  
Notary's No. 518-Register's No. 228  
Qualification Expires August 1st, 1922



UNITED STATES PATENT OFFICE.

Division 16 Room 712

910

PAPER NO. 9  
AMENDMENT C  
(Q.78)

30

In re application of

HAROLD D. ANNOLD

Subject

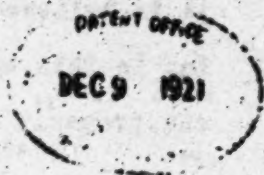
Serial No. 423,259

Filed November 11, 1920

VACUUM TUBE CIRCUITS

Allowed June 29 - 1921

THE COMMISSIONER OF PATENTS,  
Washington, D. C.



Sir;

Please amend the above entitled application as follows:

Page 2, after line 17, insert the following paragraph:

This type of connection is also useful for connecting circuits of various kinds either with the input terminals or the output terminals of a vacuum tube.

Page 2, line 27, after the period, insert This application is a continuation in part of my application Serial No. 247,422, filed July 30, 1918, now patent No. 1,329,285, dated January 27, 1920.

REMARKS-

It is believed that the above amendment to the statement of invention overcomes the Examiner's objections to the amendment presented November 14, 1921.

Claim 15 is readable not only on applicant's patent 1,114,845, cited in the Office Action of February 2, 1921, but also on patent No. 1,329,285. Since applicant has had a continuous disclosure of this subject matter in the Office

423259-26

60/17



(Serial No. 423,259)

since May 16, 1914, it is thought proper to term this application a continuation in part of the last mentioned patent which itself refers back to an application filed May 28,

1914. The above patents show a vacuum tube connected by means of the coupling set forth in claim 15, in one case to a receiver and in the other case to a line transformer and it is believed to be unnecessary to make any additional showing in this application. It is believed that this amendment can properly be admitted under the Provisions of Rule 78.

Respectfully

HAROLD D. ARNOLD

By *Chas. Sprague*  
Attorney

ENTRY RECOMMENDED  
UNDER RULE 78

463 West Street

New York, Dec 7, 1921

*A. D. B. Smith*  
EXAMINER

Entry Approved

DEC 15 1921

*John E. Robinson*  
Commissioner of Patents

HAY:3

- 2 -

60/18

NUMBER (Series of 1915),

1919

(EXTS BOOK) 283-2-8

1448550

DIV.

16

PATENT No.

Name *Harold D. Arnold* MAR 13 1919  
*Assoc. to Western Electric Company, Incorporated,*  
*of New York, N. Y., a corp. of New York*

of *Maplewood*  
 County of *New Jersey*  
 State of *New Jersey*  
 Invention *Thermionic Amplifier Circuits*

ORIGINAL

RENEWED

Petition	<i>Feb 3, 1919</i>		
Affidavit	<i>" " 1919</i>		
Specification	<i>" " 1919</i>		
Drawing	<i>" " 1919</i>		
Photo Copy	<i>" " 1919</i>		
First Fee Cash	<i>15.00 Feb 3, 1919</i>		
" " Cert.	<i>" " 1919</i>		
Appl. filed complete	<i>Feb 3, 1919</i>		
Examined and Passed for Issue	<i>Sept 6, 1922</i>		
Notices of Allowance	<i>Sept 7, 1922</i>		
Final Fee Cash	<i>20 Feb 15, 1923</i>		
" " Cert.	<i>" " 1923</i>		

Patented *Mar 13 1923*  
 Attorney *DeWitt, Tanner and John J. Roberts*  
 Associate Attorney *W. C. Beatty*  
*Ch. Sprague, 463 West 42nd St. New York, N. Y.*  
 No. of Claims allowed *(2)* Print Claims  
 Title as allowed *Thermionic Amplifier Circuits*  
 Address *463 West 42nd St. New York, N. Y.*



1       The invention relates to repeater circuits  
2 wherein an electron-discharge device is employed for  
3 receiving comparatively weak incoming impulses and  
4 for transmitting them in the same form or in a modified  
5 form but with amplified energy. Such an amplifier  
6 which has a cathode, an anode and a control  
7 member usually in the form of a grid electrode, has  
8 a very high impedance between control member and  
9 cathode which are the usual input electrodes. This  
10 impedance is of the order of 25,000 ohms or more being  
11 in the nature of a space-discharge path between electrodes  
12 in a vacuum. Preferably, the vacuum is as perfect  
13 as practicable, substantially no positive ionisation  
14 taking place during the operation of the device.  
15 In case a source of potential is employed for making  
16 the potential of the grid always negative, the input  
17 circuit impedance is of the order of infinity, for  
18 no electrons can flow from the filament to an electrode  
19 which is negative, so that no current flow  
20 takes place between cathode and grid even though the  
21 latter does respond to the incoming potential variations.  
22

23       An object of the present invention is to modify  
24 the effect of this high input impedance so that it  
25 may have any desired finite value.

26       This is accomplished by connecting the incoming  
27 line to the repeater through a transformer, the secondary  
28 coil of which is shunted by a high impedance preferably  
29 a resistance of the order of 500,000 ohms and may,  
30 for instance, range from approximately 100,000 ohms to  
31 1,000,000 ohms. This resistance is also in shunt to

1 the input electrodes. The impedance between the in-  
2 put electrodes may be made much higher than 500,000  
3 ohms by a battery or other source which maintains the  
4 grid negative. The impedance at the secondary side  
5 of the transformer is practically that of the 500,000  
6 ohm resistance, as the higher impedance path between  
7 the input electrodes takes practically no current or  
8 at least a negligible current.

9 By this arrangement the same amplification can  
10 be secured with amplifier tubes having different input  
11 impedances, and it is feasible to substitute one such  
12 tube for another in a given circuit arrangement.

13 More uniform amplification may also be secured  
14 by this arrangement with varying input power. In the  
15 use of amplifier circuits heretofore designed it has  
16 been found that there is a tendency for small input  
17 voltages to be amplified proportionately more than  
18 large input voltages, for the reason that the input  
19 impedance of the tube is greater for small voltages  
20 than for large voltages, especially when no means is  
21 employed for maintaining the control electrode negative  
22 with respect to the cathode. By the use of a shunt  
23 path of constant resistance less than that between the  
24 input electrodes this tendency is substantially eliminated.

25 Aside from the above mentioned advantages of us-  
26 ing the shunt impedance, it has the advantage, regardless  
27 of the function of the vacuum tube or of the circuit in  
28 which it is connected, of preventing singing of the  
29 repeater in case the output and input circuits thereof  
30 are coupled either designedly by an inductive coupling  
31 for instance, or accidentally by reason of the proximity



1 of the input and output leads of the repeater.

2 A further advantage inherent in the use of a  
3 high impedance shunt between the line and the repeater  
4 is that it is possible to employ vacuum tubes having  
5 different but high impedances in the same circuit  
6 without substantially affecting the impedance of the  
7 circuit as seen from the primary side of the trans-  
8 former.

*Ex. 2. Audit.*

9 This application is a continuation <sup>in part</sup> of applica-  
10 tion, Serial No. 89,210, filed November 2, 1914, and of  
10 application Serial No. 48,875, filed September 3, 1915,  
11 For further details of the invention, reference  
12 may be made to the drawings in which the single figure  
13 illustrates diagrammatically a repeater circuit embody-  
14 ing the invention.

15 Referring in detail to the figure, the incoming  
16 line 1 is adapted to be traversed by weak incoming im-  
17 pulses which are to be amplified by the amplifier 2,  
18 and to be sent out in amplified form upon the line 3.  
19 Preferably, there is employed the battery 4 or other  
20 source which maintains the grid negative with respect  
21 to the anode, in which case the input impedance of  
22 the repeater is practically infinite, as described  
23 above. The line 1 is connected to the input elec-  
24 trodes of the repeater which, in this case, are the  
25 grid and cathode electrodes, by the repeating coil  
26 or transformer 5. In shunt to the secondary of the  
27 repeating coil 5 and also in shunt to the input elec-  
28 trodes is the impedance 6, which may be non-inductive  
29 as shown and in the form of a resistance of the order  
30 of 500,000 ohms. This resistance may assume any de-  
31 sired form; viz, it may be a wire resistance, a lavite

1 resistance, or a piece of paper treated with india ink  
2 and sealed in a glass tube. The battery 7 in the out-  
3 put circuit of the repeater supplies space current  
4 through the choke coil 8 and between cathode 9 and anode  
5 10. If desired, the output circuit of the repeater  
6 may be coupled to the line 5 by the repeating coil 11,  
7 as shown. (X)



## WHAT IS CLAIMED IS:

Issue

Per B

" B

Per A

(Sub. A)

" A

Insert A

" A

" A

Insert A

" B

Insert A

Insert A

1. The combination of a vacuum discharge ~~repeater~~ <sup>*of the three-electrode type*</sup> having input electrodes, an inductive coil conductively connected to <sup>*the*</sup> said input electrodes, <sup>*of said repeater*</sup> and an impedance in shunt to said coil,

2. The combination of an incoming line, <sup>*having input electrodes*</sup> a repeater, a transformer coupling said line to said repeater, <sup>*a conductive*</sup> and an impedance in shunt to one of the coils of said transformer.

3. The combination of an incoming line, <sup>*having input electrodes*</sup> a repeater, a transformer coupling said line to said repeater, <sup>*a conductive*</sup> and an impedance in shunt <sup>*said*</sup> to the secondary coil of said transformer.

4. The combination of a line, a vacuum tube amplifier <sup>*of the three-electrode type*</sup> connected thereto, said amplifier having input terminals <sup>*1*</sup> and a high resistance connected to said terminals.

5. The combination of a line, a vacuum tube amplifier connected thereto, said amplifier having grid and cathode electrodes <sup>*2*</sup> and a resistance of the order of 100,000 ohms <sup>*3*</sup> forming a by-path between said electrodes.

6. The combination of a vacuum tube amplifier having grid and cathode electrodes, means for making the potential of said grid negative with respect to said cathode, and a high resistance by-path for said electrodes.

7. The combination of a line, a vacuum tube amplifier, a transformer for connecting said line to said amplifier, and a by-path between said line and said amplifier and having an impedance of the order of 500,000 ohms, <sup>3</sup> <sub>2</sub> <sup>5</sup>

8. The combination of an incoming line, a repeater having a cathode and an anode, means for supplying a space current between said electrodes, a member for controlling said space current, <sup>3</sup> <sub>2</sub> and means between said line and said repeater for making the impedance of the repeater as seen from said line, substantially of a constant value.

9. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a space current between said electrodes, a grid electrode for controlling said space current, means for making said grid negative with respect to said cathode, and means between said line and the input electrodes for making the impedance of said amplifier as seen from said line, substantially of a constant value.

10. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a space current between said electrodes, a grid electrode for controlling said space current, means for making said grid negative with respect to said cathode, a transformer for connecting said line to said amplifier, and a high resistance in shunt to the secondary winding of said transformer and to said grid and cathode

Insert A<sup>5</sup>

Insert A<sup>6</sup>

OK

OK



electrodes for making the impedance of said amplifier as seen from said line, substantially of a constant value.

Per A

~~11. The combination of a line, an amplifier in circuit therewith having an input impedance at least as high as 10,000 ohms, and a shunt between said line and said amplifier having an impedance of an order lower than that of the input impedance of said amplifier.~~

// 12. The combination of a line, an amplifier in circuit therewith having an input impedance at least as high as 100,000 ohms, and a shunt between said line and said amplifier having an impedance of an order lower than that of the input impedance of said amplifier.

12. 13. The combination of a line, an amplifier in circuit therewith having an input impedance which is practically infinite, and a shunt between said line and said amplifier having an impedance of the order of 500,000 ohms.

Insert A 7

1c  
 IN WITNESS WHEREOF, I hereunto subscribe my name  
 this 15<sup>th</sup> day of January, A. D. 1919.

Harold D. Arnold

Q A T H

State of New York

County of New York

} ss.

HAROLD HARVEY ARNOLD, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of Maplewood, in the County of Essex and State of New Jersey, and that he verily believes himself to be the original, first, and sole inventor of the improvement in THERMIONIC AMPLIFIER CIRCUITS, described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the applications of which this is a continuation, or in public use or on sale in the United States for more than two years prior to the applications of which this is a continuation; that the said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to the applications of which this is a continuation; and that no application for patent on said improvement has been filed by him or his legal representatives or assigns in any country foreign to the United States.

Harold D. Arnold

Sworn to and subscribed before me

this 15<sup>th</sup> day of January, 1919.

Elmer S. [Signature]  
 Notary Public



"The Commissioner of Patents,  
Washington, D. C.,"  
and not any official by name.

JLP:LBG

Applicant should give true correct names,  
date of filing, date of invention, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

July 10, 1919

Mr. John G. Roberts,

920 Broadway,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold D. Arnold, Ser. #274,950, filed Feb. 3, 1919.

Thermionic Amplifier Circuits.

James S. Newton  
Commissioner of Patents

This application has been examined.

The specification is indefinite as to the frequency at which the various values of impedance stated are effective. Inasmuch as impedance is more generic in meaning than a simple non-inductive resistance, it fails to convey the proper significance unless the factor of frequency is stated.

Claims 7 to 13 inclusive are objected to for the above reasons in that the claims purport to describe something other than non-inductive resistance and yet fail to specify a term, namely frequency, which is necessary in order to give some significance to the word impedance.

The following references are made of record:

✓ STONE ET AL,	884,110, April 3, 1908, 250-27;
✓ COLPITTS,	1,129,959, March 2, 1916, 179-171;
LANGMUIR,	1,223,496, Apr. 24, 1917, 179-171;
✓ COLPITTS, Reissue	14,380, Oct. 23, 1917, 179-171.

Claims 1 to 13 inclusive are rejected on Colpitts reissued patent, attention being called to Fig. 2 of Colpitts, wherein the resistance 26 shunts the secondary coil 14 of transformer 15. Although the amplifier shown is not a simple form, it amplifies the input signal.

Claims 1, 2 and 3 are rejected on Stone et al. cited.

Claims 4, 5, 6, 8, 9, 11, 12 and 13 are rejected on Langmuir, cited, attention being called to resistance 4.

Claim 1 is rejected on Colpitts 1,129,959, wherein the inductive coil 53 or 55 is conductively connected to the electrodes 11, 23, and the impedance of the output circuit of the tube 3 is in shunt of these coils.

Claims 11 and 13 are not considered allowable over claim 11, differing merely in degree.

Examiner, Div. 16.

MAIL ROOM  
JUN 18 1920  
PATENT OFFICE

922

PAPER NO. 6

BY EXAMINER

UNITED STATES PATENT OFFICE

Division 18 Room 112

0011

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 274,750

Thermionic Amplifier Circuits

Filed February 3, 1919



THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of July 10, 1919,  
please amend the above-entitled application as follows:

Claim 1, line 4, and claims 2 and 3, line 3, cancel  
"an" and substitute therefor --a conductive--.

Claim 2, line 2, after the word "repeater", insert  
--having input electrodes--; line 5, after the comma,  
insert --one coil of said transformer being conductively  
connected to said electrodes--.

Claim 3, line 2, after "repeater" insert --having  
input electrodes--; line 3, after the comma, insert --the  
secondary coil of said transformer being conductively con-  
nected to said electrodes--; same line, change "the" to  
said--; line 4, cancel "of said transformer".

Claim 4, line 3, after the comma, insert --means for  
applying a steady difference of potential between said  
input terminals--.

Claim 5, line 3, after the comma, insert --means  
for applying a steady difference of potential between  
said electrodes--.

Claim 7, line 3, cancel "and"; line 5, change the



(Serial No. 274,750)

✓ period to a comm and add --/and means for maintaining the impedance of said amplifier greater than that of said by-path.

Claim 8, line 5, after the comm, insert --/means for applying a steady difference of potential between said cathode and said control number.

✓ Cancel claim 11.

Renumber claims 12 and 13 as 11 and 12, and add the following:

--13. An incoming line, a thermionic amplifier, means comprising a symmetrically conducting aperiodic circuit between said line and said amplifier whereby the currents in said line are adapted to be accurately reproduced in augmented form.--

--14. The combination of a symmetrically conducting aperiodic circuit, a vacuum tube having input terminals and an output circuit, and connections between said aperiodic circuit and said input terminals.--

### REMARKS

Reconsideration of the objection to claims 7 to 13 on the ground that the word "impedance" is improperly used, is respectfully requested. "Impedance" is a generic word which includes within its meaning reactance and resistance. If it is desired to substitute an inductance for the resistance 6 in the drawing, it is a simple matter to calculate the proper value for the inductance which will give the desired impedance for

(Serial No. 274,750)

the frequency to be used. It is, moreover, possible to design a network of reactances which will have a constant impedance throughout a wide range of frequencies. An example of such a network is the filter disclosed in Campbell patent No. 1,227,114, dated May 22, 1917. This filter is designed to have a constant impedance throughout substantially the entire range of the filter. Theoretically, moreover, a network could be designed which would be of constant impedance throughout an infinite number of frequencies. The applicant has disclosed one form of impedance which remains constant throughout the range of frequencies to be employed, and it is believed that this amounts to a sufficient disclosure to warrant the claims now in the case.

An affidavit is filed herewith carrying the date of applicant's invention back of the filing dates of the Colpitts and Langmuir patents of record. The date of invention is earlier also than the filing date of Langmuir patent No. 1,227,193, dated March 1, 1919, original filing date October 29, 1915, which has certain features in common with applicant's circuit.

Claims 1, 2, and 3 have been amended to distinguish over the Stone patent of record.

Claim 11 has been cancelled, but original claims 12 and 13 have been retained. Claim 12, formerly 13, differs from claim 11, formerly 12, in the limitation that the input impedance of the amplifier is substantially infinite. The impedance is made infinite by applying a negative potential to the grid, and it is believed that this limitation renders the claims patentably different.



Serial No. 274,750)

New claims 13 and 14 were allowed as presented by amendment of August 22, 1919 in the application of B. W. Kendall, Serial No. 149,782, filed February 20, 1917. It has been discovered that the applicant is the prior inventor of the subject-matter of these claims, rather than Mr. Kendall, and it is believed that the claims are allowable in this application.

Favorable consideration and allowance of the application as amended is respectfully requested.

Respectfully,

HAROLD D. ARNOLD

By W. Beattie  
Attorney

403 West Street,

New York, N.Y., June 5<sup>th</sup>, 1920.

HAW:BN

in re application of

HAROLD D. ARNOLD - Filed February 3, 1919 - Serial No. 274,750 -  
Subject - THERMIONIC AMPLIFIER CIRCUITS.

O A T H

STATE OF NEW YORK }  
COUNTY OF NEW YORK } ss.

Patent Office

JUN 30 1920

HAROLD D. ARNOLD being duly sworn, deposes and says:

That he is the applicant in the above-named application; that the circuit shown on the attached blue-print marked ES-95922 represents a vacuum tube amplifier circuit which was set up and tested under his direction prior to October 29, 1915; that a resistance of 240,000 ohms was connected in shunt to the secondary of the input transformer and to the input electrodes of the vacuum tube; that the circuit with said resistance in circuit was tested with currents of a frequency within the voice range; that said currents were amplified in a satisfactory manner; that said blue print is a copy of a drawing which was made prior to October 29, 1915;

That he does not know and does not believe that the invention has been in public use or on sale in this country or patented or described in any printed publication in this or any foreign country for more than two years prior to his original application, of which this is a continuation; and that he has never abandoned the invention.

*Harold D. Arnold*

Sworn to and subscribed before

me this 26th day of June, 1920

*Walter J. [Signature]*  
Notary Public.

NEW YORK COUNTY  
COUNTY CLERK'S OFFICE  
RECEIVED JUNE 30 1920

BY CLERK'S OFFICE JUNE 30 1920

APPROVED  
JUN 30 1920  
[Signature]



827

Sketch No. ES 93922

# AUDION

-26-

PLATINUM - BAR IN

INPUT VS OUTPUT

INPUT VS EFFICIENCY

COMPARISON OF C BATTERY  
AND SHUNT RESISTANCE OF  
240,000 OHMS

IN BOTH CASES

FILAMENT

2.4 VOLTS

0.35 AMPERE

SPACE

2V VOLTS

280-660 10<sup>6</sup> OHM

EXTERNAL RESISTANCE

30,000 OHMS

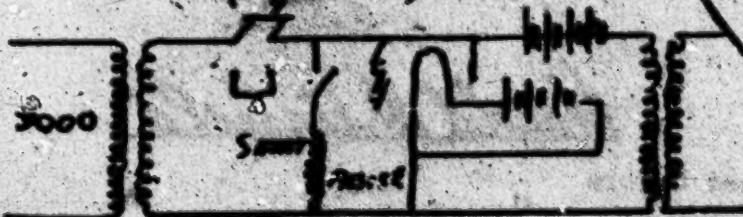
7000  
6000  
5000  
4000  
3000  
2000  
1000

OUTPUT IN MICROWATTS

STRAIGHT CIRCUIT

THE CIRCUIT

C battery



C BATTERY = 2.4 VOLTS

SHUNT RESISTANCE 240,000

STRAIGHT CIRCUIT

C BATTERY = 2.4 VOLTS

SHUNT RESISTANCE = 240,000

INPUT IN VOLTS A.C.

0.5 1.0 1.5 2.0 2.5 3.0 3.5

900

800

700

600

500

400

300

200

100

0

928

Reply No 7

"The Commissioner of Patents,  
Washington, D. C.,"  
and not any official by name.

Application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Oct. 13, 1920

Mr. John C. Roberts,

403 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

H. D. Arnold,

Ser. #274,750, filed Feb. 3, 1919.

Thermionic Amplifier Circuits.

ROBT. F. WHITEHEAD

Commissioner of Patents.

This action is responsive to amendment filed  
June 29, 1920.

Claims 1 to 5, 8 and 11 are rejected as failing to  
distinguish patentably from

LINDRIDGE, 1,047,956, Dec. 24, 1912, 179-171 Gas.

It will be noted that choke coil 11 of the reference consti-  
tutes a "conductive impedance"; and, furthermore, may be made  
of any magnitude even as high as 100,000 ohms. Regarding  
claims 4 and 5, the high resistance is read on the unilateral  
conductive element 2.

Claims 13 and 14 are rejected as misdescriptive in  
calling for "an aperiodic circuit". It is thought there is  
sufficient capacitance between the individual coils of the  
secondary and inductance of the whole to preclude the possi-  
bility of claiming a pure aperiodic circuit.

All other claims appear allowable.

Ext., Div. 16.

NWB.

61/17



929

UNITED STATES PATENT OFFICE

Division 16 Room 118

PAPER NO 9  
AMENDMENT B

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 274,750

Filed February 3, 1919

Thermionic Amplifier Circuits

THE COMMISSIONER OF PATENTS,  
Washington, D. C.



Sir:

In response to the Office Action of October 13, 1920, please amend the above entitled application as follows:

Claim 1, line 2, cancel "having input electrodes" and substitute therefor --of the three-electrode type--; line 3, change "said" to --the--; same line, after "electrodes" insert --of said repeater--.

Rewrite claims 2 and 3 as follows:

2. The combination of an incoming line, an electric discharge repeater of the three-electrode type, a transformer coupling said line to said repeater, one coil of said transformer being conductively connected to the input electrodes of said repeater, and a conductive impedance in shunt to one of the coils of said transformer.

3. The combination of an incoming line, an electric discharge repeater of the three-electrode type, a transformer coupling said line to said repeater, the secondary coil of said transformer being conductively connected to the input electrodes of said repeater, and a conductive impedance in shunt to said secondary coil.

Let 4 fols

W/18

(Serial No. 274,750)

✓ Claim 4, line 2, after "amplifier" insert --of the three-electrode type--.

✓ Cancel claims 13 and 14.

### REMARKS

Claims 1, 2, 3 and 4, as amended, and claims 5, 6 and 11, as previously worded, are thought to clearly distinguish from the Lindridge patent cited in the last Office Action. Claims 1 to 5 and 8 are limited to a repeater of the three-electrode or so-called audion type. The discharge device of Lindridge which is alleged to act as a repeater is of the two-electrode type and incoming potentials are impressed across the ends of the filament. Although Lindridge shows six tubes with their filaments connected in series, it is not believed that the input impedance of the whole device is more than thirty or forty ohms, since in electron discharge devices of which the applicant is aware, the resistance of individual filaments is of the order of six ohms. The impedance 11 of Lindridge, if as stated by the Examiner may have an impedance of 100,000 ohms at some frequency in the voice range, could not have the functions of applicant's resistance 6. Claim 8 is further limited to a condition where changing from one tube to another of a different impedance does not change the impedance of the repeater as seen from the line. This is not true in the low impedance repeater of Lindridge. Claim 11 specifically states that the input impedance of the amplifier is 100,000 ohms or more. In view of the fact



(Serial No. 274,750)

that each of these claims contains material structural differences over Lickridge and that these differences contribute to a new result, it is believed that the Examiner will see his way clear to allow these claims.

In view of the rejection of claims 13 and 14 as misdescriptive, these claims have been cancelled and will be reinserted in the application of B. W. Kendall, Serial No. 145,782, filed February 20, 1917. These claims were inserted in this case for the reason that the applicant was in doubt as to whether they could be properly based on the disclosure in this case. The applicant now agrees, however, with the Examiner's position that they are misdescriptive of his arrangement.

Respectfully

HAROLD D. ARNOLD

By *Chas. Sprague*  
Attorney

463 West Street

New York, October 8, 1921

Div. 16, Room 118

HHD:220:

Paper No. 10

All communications regarding this application should give the serial number, date of filing, title of invention, and name of the applicant.

Address only  
"The Commissioner of Patents,  
Washington, D. C."  
and not any official by name.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Sept. 7, 1922

EXAMINER'S AMENDMENT

Mr. John G. Roberts,

445 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

H. D. Arnold,

Ser. #874,780, filed Feb. 5, 1919.

Thermionic Amplifier Circuits.

THOS. E. ROBINSON, Examiner.

In accordance with the provisions of Order No. 2300, dated March 12, 1917, which reads in part as follows:

Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

the changes, hereinafter specified, are made by the examiner in the application above identified. Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed. The application has been amended as follows:

Page 4, line 9, in part is inserted after "continuation".

*Q. H. [Signature]*

Exr., Div. 16.

6/21



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**PAGE**

933

## PLAINTIFF'S EXHIBIT NO. 62

NUMBER (Series of 1915),  
406695

1920

(EXTS BOOK) 74-8-9

DIV. 16

PATENT NO.

1465382

Name Harold D. Frost Agent  
Assoc. to Western Electric Company, Incorporated, of  
New York, N. Y., a corp. of New York

of Maplewood

County of

State of

New Jersey

Invention

Vacuum Tube Amplifiers

ORIGINAL

RENEWED

Petition Aug 28 1920  
 Affidavit " " 1920  
 Specification " " 1920  
 Drawing " " 1920  
 Photo Copy Aug 1 1922  
 First Fee Paid 15 Aug 28 1920  
 " " Cert. 1920  
 Appl. filed complete Aug 28 1920

17 1920  
14 1920  
11 1920  
7 1920  
26 1920  
29 1920

Examined and Found for Issue Mar 11 1923

H. Barker Esq. Div. 16

Notice of Allowance Mar 23 1923

Final Fee Paid July 21 1923

" " Cert. 1923

Patent 1923

Attorney De Witt C. Tanner by John E. Roberts

Associate Attorney H. L. Burt 463 Hudson Street New York N.Y.

J. C. R. Palmer

No. of Claims Allowed 1 - Print Claim

Title as allowed Vacuum Tube Amplifier

Chatter

In O. U. (CI 179-171)



1 This invention relates to vacuum tube amplifiers,  
2 and more particularly to arrangements for supplying space  
3 current thereto.

4 An object of this <sup>invention</sup> invention is to provide means  
5 whereby a plurality of vacuum tubes to be used as repeaters  
6 or amplifiers may be supplied with space current from a single  
7 source, but in such a manner that current changes in one tube  
8 due to signals being repeated cannot be impressed on another  
9 tube through said source.

10 With the arrangement shown herein, a single  
11 source of space current is used to energize both tubes  
12 of a two stage amplifier, and in the branches of the circuit  
13 therefore are interposed filters of series inductance and shunt  
14 capacity to prevent alternating current from being bypassed  
15 there-through.

16 The invention described and claimed herein is  
17 divided out of my applications, Serial No. 48,874, filed  
18 September 3, 1915, and Serial No. 285,887, filed March 28, 1919.

19 For further details, reference may be made to the  
20 accompanying drawings in which the single figure illustrates  
21 diagrammatically a two stage amplifier embodying the inven-  
22 tion.

23 Referring to the drawing by reference numerals,  
24 the amplifier set comprises a tandem arrangement of two  
25 vacuum tubes 10 and 11 each having cathode 12, a grid or  
26 control electrode 13, and an anode 14. The cathodes 12 are  
27 maintained in a condition of thermionic activity by currents  
28 from source 15.

29 The input circuit of tube 10 comprises terminals  
30 16, 17, adapted to be connected to a suitable source of electric  
31 impulses to be repeated, a resistance 18 bridged across the

1 input electrodes, and a battery 19 adapted to maintain  
 2 the grid electrode at a negative potential with respect to  
 3 the cathode. Current between the anode and cathode is sup-  
 4 plied from battery or other suitable source 20, the current  
 5 passing in series through the inductance 21 and the transformer  
 6 primary 22. A shunt condenser 23 provides a path for the alter-  
 7 nating current.

8 The transformer secondary 24 has connected across  
 9 its terminals a resistance 25, one end of which is connected  
 10 to the cathode of tube 11. A connection from resistance 25 to  
 11 the grid of tube 11 comprises the movable contact 26 and the  
 12 battery 27, the function of the latter being to provide the neces-  
 13 sary negative potential on the grid.

14 Direct current is supplied to the tube 11 from  
 15 source 20, through inductances 28 and 29, and grounds 30 and  
 16 31. Condenser 32 is shunted across the direct current circuit.  
 17 The output circuit for alternating current comprises the  
 18 condenser 33 and the primary 34 of a transformer, the second-  
 19 ary 35 of which is adapted to be connected through terminals  
 20 36 and 37 to any suitable receiving circuit.

21 In operation, the signals or other impulses, which  
 22 are repeated and amplified by the tube 10, are impressed on the  
 23 resistance 25 by currents induced in the secondary coil 24.  
 24 X The input electrodes of the second tube are shunt to <sup>an</sup> ad-  
 25 justable part of the resistance 25, and therefore any de-  
 26 sired proportionate part of the potential drop across the  
 27 resistance may be impressed between the input electrodes, with  
 28 the result that the ratio of amplification may be varied be-  
 29 tween a predetermined maximum and zero.

30 The series inductances 21 and 29 and the shunt  
 31 condensers 23 and 32 serve to prevent potential variations



1 from the source or from either tube from being impressed  
2 through the supply circuit on the other tube.

3 While I have shown and described one embodiment  
4 of the invention, it is <sup>obvious</sup> ~~obvious~~ that it may assume any desired  
5 form within the scope of the appended claims.

Per X B

(X)

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## WHAT IS CLAIMED IS:

1. In combination, a plurality of vacuum tube repeaters, and a common source of space current for said repeaters, the circuit between one of said repeaters and said source comprising series inductance, <sup>a path comprising</sup> and ~~shunt~~ <sup>bridged across said circuit between said source and said repeater</sup> capacity.

2. In combination, a plurality of vacuum tube repeaters, and a common source of space current for said repeaters, the circuit between each of said repeaters and said source comprising series inductance, <sup>a path comprising</sup> and ~~shunt~~ capacity.

3. In combination, a plurality of vacuum tube repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from one of said repeaters from flowing in the portion of the space current circuit common to said repeaters.

4. In combination, a plurality of vacuum tube repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from flowing from each said repeaters to the others of said repeaters through the portion of the space current circuit common to all.

5. In combination, a source of current, branched circuits therefrom to a plurality of vacuum tube repeaters, ~~are~~ <sup>are</sup> supplying space current thereto, and a wave filter in each of said branches.

6. The combination in an amplifying system of a plurality of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid



circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers, and a filter connected between said source and said plate circuits for eliminating the effect in said plate circuits of potential variations in said source.

7. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuit of all of said amplifiers in succession from the last to the first, and a filter connected between said source and the plate circuit of the last of said amplifiers for eliminating the effect in said plate circuits of potential variations in said source.

8. In a multi-stage amplifier, a plurality of vacuum tubes connected in tandem, a common source of space current for said tubes, *branch circuits connecting said source and said tubes in one of said circuits*, and a filter comprising series inductance and shunt capacity *bridged across the path containing* between one of said tubes and said source.

9. In a multi-stage amplifier, a plurality of vacuum tubes connected in tandem, a common source of space current for said tubes, *branch circuits connecting said source and said tubes in each of said circuits*, and a filter comprising series inductance and shunt capacity *a path containing bridged across each of* between each of said tubes and said source.

10. In combination, a plurality of vacuum tube translating devices, a common source of potential for said vacuum tubes, a circuit connecting each of said tubes to said source containing series inductance and shunt capacity *a path comprising bridged across each of*.

11. In combination, a plurality of vacuum tube translating devices, a common source of current for

and a path comprising capacity bridged across connecting energizing said tubes, each of the circuits/said tubes to said source comprising shunt capacity.

12. In combination, a plurality of vacuum tube translating devices, a common source of current for energizing said tubes, each of the circuits connecting said tubes to said source comprising series inductance.

13. In combination, a plurality of vacuum tube translating devices, a common source of space current for said tube, each of the circuits connecting said tubes to said source comprising series impedance and shunt capacity.

14. In combination, a plurality of vacuum tube translating devices, a common source of space current for said tube, a filter comprising and inductance element and a capacity element between each of said tubes and said source, one of said elements being in shunt and one in series.

9 12 15. In combination a plurality of vacuum tube translating devices, a common source of current for energizing said vacuum tubes, each of the circuits between said tubes and said source comprising series impedance, and <sup>a</sup> shunt capacity <sup>effectively in shunt to said source</sup> for preventing interference between said tubes.

Insert a: Feb 10-11



In Witness Whereof, I hereunto subscribe my name  
 this 25<sup>th</sup> day of August A. D., 1920  
Harold De Forest Arnold

## OATH.

State of New York  
 County of New York

ss.

HAROLD DE FOREST ARNOLD

the above named petitioner, being duly sworn, deposes and says that he is a  
 citizen of the United States, and resident of Englewood

in the County of Essex

and State of New Jersey

and that he verily believes himself to be the original,  
 first, and sole inventor of the improvement in

VACUUM TUBE AMPLIFIERS

described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that the said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said improvement has been filed by him or his legal representatives or assigns in any country foreign to the United States, except as follows:

Harold De Forest Arnold

Sworn to and subscribed before me  
 this 25<sup>th</sup> day of August 1920

Jacob H. Gilbert  
 Notary Public.

911

Case 36-A  
PAPER No 2  
AMENDMENT  
TO  
Oath

## UNITED STATES PATENT OFFICE.

Division \_\_\_\_\_ Room \_\_\_\_\_

1921

In re application of

HAROLD DEFOREST ARNOLD

Subject.

Serial No. 406,695

Vacuum Tube Amplifier

Filed August 28, 1920

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

JAN 17 1921

Sir:

Please amend the above entitled application as follows : -

✓ Add the following claims : -

10. ~~10~~ <sup>16</sup> 16. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers in succession from the last to the first of said amplifiers, and filter connections between successive amplifiers of the series.

11. ~~11~~ 17. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the



(Serial No. 406,695) - 2

plate circuits of all of said amplifiers, and filter connections between successive amplifiers of the series.--

## R E M A R K S

✓ A new oath is filed herewith which is appropriate to a divisional application.

New claims 16 and 17 added by this amendment, are believed to be allowable along with the claims already in the case. These claims and original claims 6 and 7 were copied from Canadian patent No. 196,389, issued January 20, 1920.

Respectfully,

HAROLD DEFOREST ARNOLD

By

W. B. Bestly  
Attorney

463 West Street.

New York, January 14, 1921.

HAW:SI

MAIL ROOM  
JAN  
1921

UNITED STATES PATENT OFFICE

In re Application of

HAROLD DEFOREST ARNOLD

Vacuum Tube Amplifiers

Serial No. 406,695

Filed August 28, 1920

Q A T H

State of New York )  
County of New York ) ss.

HAROLD DEFOREST ARNOLD, the applicant in the above entitled application, being duly sworn, deposes and says that he is a citizen of the United States, and resident of Maplewood, in the County of Essex and State of New Jersey, and that he verily believes himself to be the original, first and sole inventor of the improvement in VACUUM TUBE AMPLIFIERS, described and claimed in the above entitled application; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the application of which this is a division, or in public use or on sale in the United States for more than two years prior to the application of which this is a division; that said invention has not been patented in any country foreign to the



United States on an application filed by him or his legal representatives or assigns more than twelve months prior to the application of which this is a division; that no application for patent on said improvement has been filed by him or his legal representatives or assigns in any country foreign to the United States prior to the filing date of the application of which this is a division; that the subject matter claimed herein was a part of his invention disclosed in the application of which this is a division, was invented before he filed said application and has not been abandoned.

*Harold B. Frost Arnold*

Sworn to and subscribed before me

this 14 day of January, 1921.

*Jacob H. Gilbert*  
Notary Public

NOTARY PUBLIC  
New York Co., Clerk's No. 491  
Comm. Exp. March 30, 1922

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

April 6, 1921

Mr. John G. Roberts,

463 West St.,

New York, N. Y.

U. S. PATENT OFFICE  
APR 6 1921  
MAILED

Please find below a communication from the EXAMINER in charge of the application of  
H. D. Arnold, Ser. #406,695, filed Aug. 28, 1920.

Vacuum Tube Amplifiers.

THOS. E. ROBERTSON

This application, as amended, has been examined.

Page 2, line 4, correct invention.Page 4, line 4, correct obvious.

Record is made for

SCHLOMILCH ET AL,

1,087,892, Feb. 14, 1914, 250-8;

NICOLSON,

1,253,211, Feb. 8, 1918, 179-171;

MARCONI (BR)

13,248/1914, 1 sheet, 250-27;

VON LIEBEN ET AL (FR)

addition 13,726/1911, 1 sheet, 250-27.

All claims are rejected as defining nothing patent-  
able over the BRITISH patent, attention being called to Fig. 4  
thereof, which illustrates a plurality of tubes effectively in  
cascade, the plate circuits of which are fed by common source E.  
It is to be noted that there is an inductance shunted by a con-  
denser adjacent said source in each output circuit.

In claims 1, 2, 8 to 15, "series inductance and shunt  
capacity" is thought to be vague and indefinite inasmuch as it  
is not apparent whether "shunt" refers to the previously recited  
"circuit" or to the "said inductance", an example of the latter  
being shown by reference as pointed out.

Claim 14 is further rejected as being broader than



Ser. #406,695 - #2.

the disclosed invention for the reason that "shunt" and "series" would ordinarily refer to the preceding terms, "inductance" and "capacity", in the stated order; the respective relation of which is neither illustrated nor described.

*O. D. B.*

Exp., Div. 16.

*NHB*

MAIL ROOM  
MAR  
22  
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PATENT MAIL

947

Case 36-A

PAPER NO 5  
AMENDMENT (A)

UNITED STATES PATENT OFFICE.

Division 16 Room 112

1215

In re application of  
HAROLD D. ARNOLD.

Subject.

VACUUM TUBE AMPLIFIERS.

Serial No. 406,695.

Filed August 28, 1920.

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

PATENT OFFICE  
MAR 23 1922

Sir:

In response to the Office action of April 6, 1921,  
amend as follows:

✓ Page 2, line 4, correct the spelling of "invention".

✓ Page 4, line 4, correct the spelling of "obvious".

✓ Claim 1, line 2, insert a comma after "repeaters";  
cancel "and";

line 4, insert a comma after "inductance";

✓ cancel "shunt" and substitute --a path com-  
prising--;

✓ line 5, after "capacity" insert --bridged across  
said circuit between said source and said  
repeater--.

✓ Claim 2, line 2, insert a comma after "repeaters";  
cancel "and";

✓ line 4, insert a comma after "inductance";

✓ cancel "shunt" and substitute --a path  
comprising--;

✓ line 5, after "capacity" insert --bridged across  
each of said circuits between said source  
and the respective repeaters--.



Serial No. 406,695--2.

✓ Claim 5, line 3, correct the spelling of "for".

✓ Claim 8, line 3, after the comma insert --branch circuits connecting said source and said tubes,--;

✓ line 4, after "inductance" insert -- in one of said circuits--;

✓ cancel "shunt" and substitute --a path containing--;

✓ after "capacity" insert --bridged across the circuit--.

✓ Claim 9, line 3, after the comma insert --branch circuits connecting said source and said tubes--;

✓ line 4, after "inductance" insert --in each of said circuits--;

✓ cancel "shunt" and substitute --a path containing--;

✓ after "capacity, insert--bridged across each of said circuits--.

✓ Claim 10, line 2, after "devices" insert a comma;

✓ line 4, cancel "shunt" and substitute --a path comprising--;

✓ after "capacity" insert --bridged across each of said circuits--.

✓ Claim 11, line 3, after the comma insert --and a path comprising capacity bridged across--;

✓ line 4, cancel "comprising shunt capacity."

✓ Cancel claims 12, 13 and 14, and renumber claims 15, 16, and 17, as 12, 13, and 14.

✓ Claim 12, formerly 15, line 4, after "impedance" insert a comma;

✓ cancel "shunt" and substitute --a--;

✓ line 5, after "capacity" insert --effectively in shunt to said source--.

Serial No. 406,695---3.

**REMARKS**

Applicant is unable to see how the Marconi patent of record anticipated either in spirit or in terms any of the claims as originally presented, with the exception of claim 12, which has been cancelled. The remaining claims call for a filter in the branch circuits or for a series inductance and shunt capacity. Since in the Marconi disclosure the capacity and inductance are in the same relation in the circuit, it is not understood how one of them could be in series and one in shunt. In order to render the distinction clearer, however, certain of the claims have been amended to call for a path comprising capacity bridged across the circuit. This clearly is not shown in the Marconi patent. This patent, moreover, has no equivalent means, although a common source is used for energizing the tubes, and no means is provided for preventing reaction of one tube on the other through the common connections to the source of energy. In fact the alternating current in each of the tubes is required to pass either through the source or through the circuit of the other tube. This is a result which it is an object of this invention to prevent.

It is believed that claims 3, 4, 5, 6, 7, 14, and 15, as originally worded, and claims 1, 2, 8, 9, 10, 11, and 12, as amended, are clearly patentable over the Marconi patent or any other art of which applicant is aware, and their allowance is solicited.

Respectfully

HAROLD D. ARNOLD.

463 West Street,

New York City

HAN:UR

By

*Jul Ch. Palmer*  
Attorney

March 21 1922.

617





## UNITED STATES PATENT OFFICE.

Division 16, Room 112

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 406,605

VACUUM TUBE AMPLIFIERS

Filed August 28, 1920

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

JUL 13 1922

Sir:

Supplemental to amendment of March 22, 1922, applicant has noted the issuance of patent No. 1,419,797, dated June 13, 1922 to E. F. W. Alexanderson. Claims 3 and 4 of this patent are identical with claims 13 and 14 of this application. As pointed out in the amendment presenting claims 13 and 14, the claims were copied from Alexanderson's Canadian patent.

In view of the fact that applicant's effective filing date is nearly four years earlier than Alexanderson's filing date, it is requested that the claims be allowed to applicant either with or (without) the formality of an interference.

Respectfully,

HAROLD D. ARNOLD

By

  
Attorney

463 West Street,  
New York, July 11, 1922.

HAM:AO

B-510

**INTERFERENCE.**Interference No. 47998Paper No. 7Name, Arnold, Harold DeForest.Serial No. 406695Title, Vacuum Tube Amplifiers.Filed, AUG. 28. 1920Interference with E. F. W. Alexanderson**DECISIONS OF**

Primary Examiner, \_\_\_\_\_

Dated, \_\_\_\_\_

Ex'r of Interferences, FavorableDated, Nov 23/22

Board, \_\_\_\_\_

Dated, \_\_\_\_\_

Commissioner, \_\_\_\_\_

Dated, \_\_\_\_\_

**REMARKS:**

This should be placed in each application or patent involved in interference in addition to the interference notice by Primary Examiner.



Forwarded from 15 Div. to  
Examiner of Interferences.

HHB:LBQ-213

Paper No. 8

[INTERFERENCE]

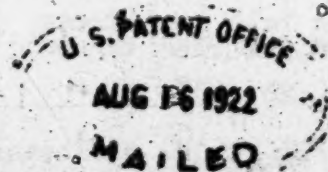
Aug. 3, 1922

DEPARTMENT OF THE INTERIOR,  
UNITED STATES PATENT OFFICE,  
WASHINGTON, D. C.

Mr. John G. Roberts,

465 West St.,

New York, N. Y.



Please find below a copy of a communication from the Examiner concerning the  
Harold D. Arnold, Ser. #406,695, filed Aug. 28, 1920; division  
of Ser. #235,857, filed Mar. 28, 1919; div. of Ser. #46,873, filed  
Sept. 3, 1915. Vacuum Tube Amplifiers.

Room No. 112

Very respectfully,

ADDRESS ONLY  
THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.

THOS. E. ROBERTSON

Commissioner of Patents.

47998

The case, above referred to, is adjudged to interfere with others, hereafter specified,  
and the question of priority will be determined in conformity with the Rules.

The statement demanded by Rule 120 must be sealed up and filed on or before

SEP 18 1922

with the subject of the invention, and name of  
party filing it, enclosed on the envelope. The subject-matter involved in the interference is

1. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers in succession from the last to the first of said amplifiers, and filter connections between successive amplifiers of the series.

2. The combination in an amplifying system of a series of electron discharge amplifiers connected in cascade, each of said amplifiers having plate and grid circuits, a common source of current for supplying current to the plate circuits of all of said amplifiers and filter connections between successive amplifiers of the series.

The interference involves your application above identified; and

A patent, No. 1,419,797, granted June 13, 1922,  
on application for Amplifying Systems, Serial No. 276,852,  
filed Feb. 15, 1919, by Ernst J. W. Alexanderson, whose  
postoffice address is General Electric Company, Schenectady.

Ser. #406,695 - 2.

New York, whose attorney is Albert G. Davis, of General Electric Company, Schenectady, N. Y., and whose assignee is General Electric Company, a corporation of New York.

The relation of the counts of the interference to the claims of the respective parties is as follows:

Counts:   Alexanderson:   Arnold:

1	3	13
2	4	14

*W. D. Backus*

Exr., Div. 16.



DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Jan. 11, 1923

Mr. John G. Roberts,

465 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold D. Arnold, Ser. #406,695, filed Aug. 28, 1920.

Vacuum Tube Amplifiers.

Thomas E. Robertson  
Commissioner of Patents.

This action is responsive to amendment filed  
March 22, 1922.

Upon careful reconsideration of this case, it is  
thought claims 3 to 7, 13 and 14 are too broad in view of  
ARNOLD, 1,129,942, March 2, 1915, 179-171 Cas;  
Fig. 6 of which discloses choke coils 17 functioning to  
prevent plate current variations in one tube from affecting  
the other through the common path of plate battery 13.  
These claims are, accordingly, rejected. With regard to  
claims 3 and 4, which apparently read directly on the pat-  
ent, the lack of dependency between the application upon  
which said patent was granted and the present application  
is noted, and this fact, in view of ex parte Mullen and  
Mullen, 50 CG 837, (class 2), appears to prevent the subse-  
quent claiming of any matter disclosed therein. In claims  
5, 6, 7, 13 and 14, it is thought "filter" may very properly  
comprise a choke coil, particularly if discrimination is  
desired between different species of current, and the claims  
are not otherwise limited. Furthermore, if applicant should  
desire to receive a network instead of a filter, he will note  
that Arnold also discloses network 17, 13, 14 between each  
tube and the common plate battery. In the light of applicant's

Ser. #408,595 - 2.

argument, claims 5, 6, 7, 13 and 14 are again rejected on the BRITISH patent for reasons of record since it is contended that a resistance with a condenser in shunt thereto clearly comes within the meaning of "filter" when looked at from the point of view of either frequency or amplitude discrimination. Applicant, undoubtedly, should limit said term since it is of very broad scope and comprises structure which may be totally different from that argued for.

All other claims appear allowable.

Inasmuch as this case has an effective filing date of seven years, a prompt response should be made, placing it in condition for final action before the examiner.

*C. O. Rackin*

Exr., Div. 16.

Q



956

Case 36-A

PAPER NO. 10  
LETTER

## UNITED STATES PATENT OFFICE

Division 16 Room 112

In re application of

HAROLD D. ARNOLD

Subject.

VACUUM TUBE AMPLIFIERS

Serial No. 406,695

Filed August 28, 1920

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

This is in response to the Office action of January 11, 1923.

Reconsideration of the rejection of claims 3 to 7, 13 and 14 on Arnold patent No. 1,129,942 is requested. It is submitted that the claims in this application which are readable on the above referred to patent are classifiable in the third class described by the Commissioner in ex parte Mullen and Mullen, 50 O.G. 857. The history of this application and of application Serial No. 285,857 from which this application was divided shows that this application was filed in response to a requirement of division in the parent case. Division was required between claims corresponding to the claims in this application and a set of claims covering a feature of the same circuit which is at least as closely related to the present claims as is the subject matter claimed in the above Arnold patent. The claims in this application relate to power supply for vacuum tubes while the claims in the patent relate to the transmission characteristics of vacuum tube circuits. As far as the invention of the patent

(Serial No. 406,005)

- 2 -

is concerned it is immaterial whether power is supplied from a common battery or from separate batteries. It is, therefore, requested that the Arnold patent be withdrawn as a reference.

Reconsideration of the rejection of claims 5, 6, 7, 13 and 14 on the British patent Marconi is also requested. The condenser and resistance combination shown in Fig. 4 in each of the plate leads is not described as being a filter and it cannot be intended to serve as a filter, since in each case it must be traversed by all the alternating currents present. (The applicant feels very strongly that he should not amend these claims, particularly claims 13 and 14 which he won in the interference with Alexanderson patent No. 1,419,797.) The British patent was of record prior to the declaration of the interference, and it is not a clear anticipation of the claims. That the claims may prove to be broad enough to read in terms on some circuit developed in the future (which is not within the equivalents of the applicant's invention) is only what occurs in a great many patents. When patents are granted it is very seldom that all the equivalents of the invention are known and it is impossible in many cases to define in words the exact equivalents of the invention. In such cases claims should be allowed which are as broad as the prior art will admit. The question of whether a particular future development is an infringement of the protected invention must necessarily be deferred until the situation arises. The patent then 62/25



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(Serial No. 406,695)

- 3 -

may be construed by the proper persons or courts.

Favorable reconsideration and allowance of  
the application is solicited.

Respectfully,

HAROLD D. ARNOLD.

By Julius H. Palmer  
Attorney

403 West Street,

New York, N. Y., Feb 10, 1935.

HAV-EN

62/26

The following is a copy of the original communication from the applicant, dated Feb. 12, 1923, and is hereby made a part of this record.

Page No. 11  
All communications concerning this application should be addressed to the Commissioner of Patents, Department of the Interior, Washington, D. C.

## DEPARTMENT OF THE INTERIOR

## UNITED STATES PATENT OFFICE

WASHINGTON

FEB. 28, 1923

Mr. John G. Roberts,

463 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of  
Harold D. Arnold, Ser. #406,695, filed Aug. 28, 1920.

Vacuum Tube Amplifiers.

*Thomas E. Robertson*

Commissioner of Patents.

This action is responsive to letter filed

Feb. 12, 1923.

Upon careful reconsideration in view of applicant's argument, claims 5, 6 and 7 are again rejected as pointing out structure unpatentable over BRITISH patent, 13,246<sup>1,914</sup> for reasons of record. It is thought that the resistances interposed between generator G, Fig. 4, and plate electrodes of tubes V, V<sub>1</sub> are such as to come within the definition of the term, "filter", particularly when this term is considered as embracing a discriminatory or limiting means of amplitude. By reference to Fig. 1 of the patent, including description thereof, the exact function of resistance R<sub>g</sub> in the several system diagrams may be determined, and it is contended that "filter" is by no means limited to that of frequency per se.

Claims 13 and 14 are deemed to be allowable in view of the statement that the filters are connected between successive amplifiers.

The patent to ARNOLD is withdrawn.

This action is made final, but the examiner will admit any amendment that will allow him to pass the case to issue.

*O. E. Robertson*  
2 x r. Div. 10



960

9

Case 36-A

PAPER NO. 12  
AMENDMENT C



UNITED STATES PATENT OFFICE.

Division 16 Room 112

In re application of

HAROLD D. ARNOLD

Subject.

VACUUM TUBE AMPLIFIERS

Serial No. 406,695

Filed August 26, 1920

MAR 10 1923

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of February 28, 1923, please amend the above entitled application as follows:  
Cancel claims 5, 6, and 7, and renumber the remaining claims in order.

R E M A R K S

The above amendment is believed to place this application in condition for allowance and such action is solicited.

Respectfully,

HAROLD D. ARNOLD,

By Julius R. Palmer  
Attorney.

445 West Street,

New York, March 7<sup>th</sup>, 1923.

MAILED

MAR 10 1923

NUMBER (Series of 1913),

285857

1919

(LX'S BOOK) 1-7-9

DIV. #4-5-1 PATENT NO. 1520994

Name Harold D. Arnold.  
Am. Co. Western Electric Company, Incorporated,  
of New York, N. Y. a corp. of New York.

County of Maplewood,  
 State of New Jersey.  
 Invention Electrodischarge  
Vacuum Tube Amplifiers

ORIGINAL

RENEWED

Petition	Mar. 28, 1919.	191
Affidavit	" " , 1919	191
Specification	" " , 1919	191
Drawing	" " , 1919	191
Photo Copy	" " , 191	191
First Fee Cash	\$15 Mar. 28, 1919.	191
" " Cert.	" " , 191	191
Appl. filed complete	Mar. 28, 1919	191
Examined and Passed for Issue	June 2, 1924	191
Notice of Allowance	July 9, 1924	191
Final Fee Cash	\$20 Dec. 1, 1924	191
" " Cert.	" " , 191	191

DEC 30 1924

Patented Dec. 30, 1924  
 Attorney De Witt C. Tamm  
463 West 41st St. New York, N. Y.  
E. W. Adams

(No. of Claims allowed 15) Print Claims 1-11 to O. O. (Cl. 179-171)  
 Title as allowed Electrodischarge Amplifiers  
 Address Maplewood, New Jersey



*electron discharge devices*

Per B

This invention relates to ~~vacuum tube~~  
 amplifiers, and more particularly to an arrangement for  
 and method of varying the ratio of amplification of *an electron discharge*  
~~vacuum tube~~ amplifier.

B

It is an object of the invention to provide  
 means whereby the ratio of amplification can be varied  
 without varying the impedance presented by the amplifier  
 as a whole to the impulses which are to be amplified.

Per A

This <sup>is</sup> accomplished in the preferred form  
 of the invention by the use of an impedance shunted across  
 the terminals of the secondary of a transformer used to  
 step up the voltage of the incoming currents. The cathode  
*an electron discharge*  
 of a ~~vacuum tube~~ of the three-electrode type is connected  
 to one end of this impedance, and a connection is made  
 from the control electrode by means of an adjustable contact  
 to a desired point on the impedance, thus varying the pro-  
 portionate part of the potential drop across the impedance  
 which is applied between the control electrode and the  
 cathode, and correspondingly varying the amplification in  
 the output circuit of the tube.

A specific feature of my invention is the incor-  
 poration of the above described controlling arrangement in  
 the output-input coupling between two stages of a multi-  
 stage amplifier. With this arrangement, a single source  
 of space current is used to energize both tubes, and in  
 the branches of the circuit therefor are interposed filters  
 of series inductance and shunt capacity to prevent alter-  
 nating current from being by-passed therethrough.

The invention described and claimed herein is  
 divided out of my application Serial No. 43,873, filed  
~~March 1, 1924~~ *Serial No. 1,504,537 August 12, 1924*  
 September 1, 1924. The invention claimed herein is

related to the invention claimed in my pending application  
*issued as patent no. 1,448,550, March 13, 1923.*  
 Serial No. 274,750, filed February 2, 1919.

For further details, reference may be made to the  
 accompanying drawings in which the single figure illustrates  
 diagrammatically a two stage amplifier embodying the invention.

Referring to the drawing by reference numerals,  
 the amplifier set comprises a tandem arrangement of two  
 vacuum tubes 10 and 11 each having a cathode 12, a grid  
 or control electrode 13, and an anode 14. The cathodes  
 12 are maintained in a condition of thermionic activity  
 by currents from sources 15.

The input circuit of tube 10 comprises terminals  
 16, 17, adapted to be connected to a suitable source of electric  
 impulses to be repeated, a resistance 18 bridged across the  
 input electrodes, and a battery 19 adapted to maintain the  
 grid electrode at a negative potential with respect to the  
 cathode. Current between the anode and cathode is supplied  
 from battery or other suitable source 20, the current  
 passing in series through the inductance 21 and the trans-  
 former primary 22. A shunt condenser 23 provides a path  
 for the alternating current.

The transformer secondary 24 has connected across  
 its terminals a resistance 25, one end of which is connected  
 to the cathode of tube 11. A connection from resistance 25  
 to the grid of tube 11 comprises the movable contact 26 and  
 the battery 27, the function of the latter being to provide  
 the necessary negative potential on the grid.

Direct current is supplied to the tube 11 from  
 source 28, through inductances 29 and 29, and grounds 30  
 and 31. Condenser 32 is shunted across the direct current  
 circuit. The output circuit for alternating current comprises



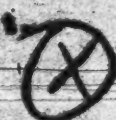
per a

1 the condenser 35 and the primary 34 of a transformer,  
2 the secondary of which is adapted to be connected through  
3 terminals <sup>36</sup> and 37 to any suitable receiving circuit.

4 In operation, the signals or other impulses,  
5 which are repeated and amplified by the tube 10, are  
6 impressed on the resistance 25 by currents induced in the  
7 secondary coil 34. The input electrodes of the second  
8 tube are in shunt to an adjustable part of the resistance  
9 25, and therefore any desired proportionate part of the  
10 potential drop across the resistance may be impressed  
11 between the input electrodes, with the result that the  
12 ratio of amplification may be varied between a predetermined  
13 maximum and zero.

14 Since the grid is at a negative potential with  
15 respect to the cathode, no current can flow therebetween,  
16 and since the capacity of these electrodes is negligibly  
17 small, the impedance of the tube to the signals is substan-  
18 tially infinite. It is thus seen that at all positions  
19 of the contact 26 the impedance of the second amplifying  
20 unit to the incoming impulses has substantially a constant  
21 value, namely, that of the finite resistance 25.

22 While I have shown and described one embodiment  
23 of the invention, it is obvious that it may assume any  
24 desired form within the scope of the appended claims. For  
25 example, the first amplifying unit with its output trans-  
26 former might be replaced by any suitable circuit adapted  
27 to have electric currents produced therein. Other modifi-  
28 cations will occur to anyone skilled in the art.



*WHAT IS CLAIMED IS:*

*an electron discharge* *comprising two electrodes*  
 1. In combination, a vacuum tube repeater, a circuit containing a source of *alternating current* electric impulses to be repeated, an impedance in shunt to said source, a connection from said circuit to an electrode of said vacuum tube, and a connection from a point intermediate the ends of said impedance to another electrode of said vacuum tube.

2. In combination, a vacuum tube repeater, an input transformer therefor, an impedance connected across the terminals of the transformer secondary, a connection from said impedance to an electrode of said vacuum tube, and a connection from a point intermediate the ends of said impedance to another electrode of said vacuum tube.

*an electron discharge*  
 3. In combination, a vacuum tube repeater having input electrodes, a circuit containing an impedance, means for impressing *voltage across* alternating current through the whole of said impedance, a connection from said circuit to one of said input electrodes, and a connection from an adjustable point on said impedance to another of said electrodes.

*An electron discharge* *an electron discharge*  
 4. A vacuum tube repeater comprising a vacuum tube having a high internal impedance, a circuit containing an impedance, means for impressing the impulses to be repeated on said circuit, and means *effectively* for connecting said internal impedance in shunt to an adjustable amount of said circuit impedance.

Sub. C.  
 Ser. B

Insert B

Sub. C.2  
 Ser. B

Insert B.2

..B  
 pr. C  
 100 7000  
 100 7000



5. A vacuum tube repeater comprising a vacuum tube having input electrodes, an input transformer, a resistance bridged across the secondary of said transformer, a connection from one of said electrodes to said resistance, and an adjustable connection from the other of said electrodes to a point on said resistance.

6. In combination, a vacuum tube having input and output electrodes, an electric circuit including a resistance connected to one of said input electrodes, a connection from an adjustable contact on said resistance to the other of said input electrodes, means for producing an alternating current through the whole of said resistance, and means connected to said output electrodes for transmitting an amplified current of substantially the same wave form as said first mentioned current.

7. In a multi-stage amplifier, a coupling between <sup>said</sup> stages comprising a resistance <sup>effectively</sup> in the output circuit of one amplifying unit, a connection from said resistance to an electrode of the succeeding amplifying unit, and a <sup>contact movable along said resistance and connected</sup> connection from an adjustable point on said resistance to another electrode of said succeeding amplifying unit.

8. In a multi-stage vacuum tube amplifier, two vacuum tubes each having a cathode, an anode, and a control electrode, a circuit containing a resistance <sup>effectively</sup> connected to the cathode and anode of one of said tubes, a connection from said circuit to the cathode of the other of said tubes, and a <sup>contact movable along said resistance and connected</sup> connection from an adjustable point on said resistance to the control electrode of said last mentioned tube.

Insert C'  
Per C

"C  
"C

Per B

"C  
"C

(X)



9. In a multi-stage vacuum tube amplifier, two vacuum tubes each having input and output electrodes and a coupling therebetween comprising a transformer having its primary connected to the output electrodes of one of said tubes, a resistance connected across the secondary of said transformer, a connection from said resistance to an input electrode of the other of said tubes, and a connection from an adjustable point on said resistance to the other input electrode of said last mentioned tube.

10. In a multi-stage vacuum tube amplifier, a vacuum tube, a resistance, means for applying changes in the output voltage of said vacuum tube across said resistance, a second vacuum tube, and means for applying a selected part of the drop in potential across said resistance to said second vacuum tube.

11. The method of operating a vacuum tube amplifier which comprises supplying alternating current to be amplified, maintaining the impedance opposed to said amplifying current substantially constant, and varying the ratio of amplification.

12. The method of operating <sup>an electron discharge</sup> a vacuum tube amplifier having input electrodes which comprises supplying alternating current to be amplified, maintaining the impedance opposed to said alternating current substantially constant and varying the ratio of amplification by applying a selected part of the potential of said alternating current to said input electrodes.

Per B

Int B

B

967



13. The method of operating a vacuum tube amplifier, which comprises supplying alternating current to be amplified, varying the ratio of amplification while maintaining the impedance opposed to said alternating current substantially constant and transmitting a current through the output circuit having substantially the same wave form as that of the incoming current.

14. The method of operating a vacuum tube amplifier having input electrodes which comprises supplying alternating current to be amplified, changing the potential of said current at a fixed ratio of transformation, and applying a selected proportionate part of the potential of the transformed current to said input electrodes.

15. In combination, a plurality of vacuum tube repeaters and a common source of space current for said repeaters, the circuit between each of said repeaters and said source comprising series inductance and shunt capacity.

16. In combination, a plurality of vacuum tube repeaters and a common source of space current for said repeaters, the circuit between each of said repeaters and said source comprising series inductance and shunt capacity.

17. In combination, a plurality of vacuum tube repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from one of said repeaters from flowing in the portion of the space current circuit common to said repeaters.

18. In combination, a plurality of vacuum tube

Inventor (s)  
Inventor A  
Per A

*cl. 17*

repeaters, said repeaters being connected in multiple to a common source of space current, and means to prevent alternating currents from flowing from each of said repeaters to the others of said repeaters through the portion of the space current circuit common to all.

*cl. 17*

19. In combination, a source of current, branched circuits therefrom to a plurality of vacuum tube repeaters for supplying space current thereto, and a wave filter in each of said branches.

---

HAM-EX  
126



970

In Witness Whereof, I \_\_\_\_\_ hereunto subscribe my \_\_\_\_\_ name \_\_\_\_\_  
this 26<sup>th</sup> day of March, A. D. 1919

Harold D. Arnold

OATH.

State of New York

County of New York

HAROLD D. ARNOLD

\_\_\_\_\_, the above named petitioner \_\_\_\_\_, being duly sworn, deposes and says that he is a \_\_\_\_\_  
citizen \_\_\_\_\_ of the United States, and resident \_\_\_\_\_ of \_\_\_\_\_  
Maplewood \_\_\_\_\_

in the County \_\_\_\_\_ of \_\_\_\_\_ Essex \_\_\_\_\_  
and State \_\_\_\_\_ of \_\_\_\_\_ New Jersey \_\_\_\_\_

and that he \_\_\_\_\_ verily believes himself \_\_\_\_\_ to be the original,  
first, and sole \_\_\_\_\_ inventor \_\_\_\_\_ of the improvement in \_\_\_\_\_

VACUUM TUBE AMPLIFIERS

described and claimed in the annexed specification; that he \_\_\_\_\_ does  
not know and does not believe that the same was ever known or used before  
his \_\_\_\_\_ invention or discovery thereof; or patented or described in any  
printed publication in any country before his \_\_\_\_\_ invention or discovery  
thereof, or more than two years prior to this application, or in public use  
or on sale in the United States for more than two years prior to this appli-  
cation; that the said invention has not been patented in any country  
foreign to the United States on an application filed by him \_\_\_\_\_ or his \_\_\_\_\_  
legal representatives or assigns more than twelve months prior to this  
application; and that no application for patent on said improvement has  
been filed by him \_\_\_\_\_ or his \_\_\_\_\_ legal representatives or assigns in  
any country foreign to the United States, except as follows \_\_\_\_\_

Harold D. Arnold

Sworn to and subscribed before me \_\_\_\_\_

this 26<sup>th</sup> day of March 1919

Walter J. Santoni  
Notary Public.

971

Div. 16      **Rec'd 112**  
The Commissioner of Patents,  
Washington, D. C.  
and not any official to whom.

1-200  
-1-2

Patent No. 28...  
All communications regarding this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

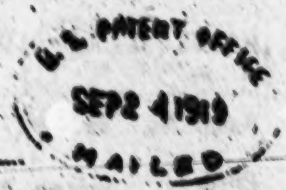
WASHINGTON

Sept. 21, 1919

Mr. John S. Roberts.

445 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of  
**Harold D. Arnold.** Ser. 4896,857, filed March 28, 1919.

Vacuum Tube Amplifiers.

*James S. Johnston*  
Commissioner of Patents.

This application has been examined.

Page 2, line 9, "ia" should be is

Page 4, line 3, "SS" should be St.

Claims 1 to 14 inclusive are specific to the impedance in control circuit of the amplifier, while claims 15 to 19 inclusive are specific to the filter connections between the common battery and the amplifier; division is required between these two groups of claims inasmuch as they cover two distinct inventions, one independent of the other, and not cooperating with each other to produce a new result as a consequence of the combination.

Record is made of the following patents:

- ✓ COLEBITE, 1,129,959, March 2, 1916, 179-171;
- ✓ MEISSNER, 1,170,552, Feb. 8, 1916, 250-27x;
- ✓ DE FOREST, 1,201,272, Oct. 17, 1916, 250-27x;
- ✓ LOGWOOD, 1,216,195, March 6, 1917, 250-27x;
- ✓ CAMPBELL, 1,227,113, May 22, 1917, 250-27x;
- ✓ LANGMUIR, 1,275,627, July 23, 1918, 250-27;
- ✓ FR. PATENT (VON LIEBOW ET AL), Addition 13,726 of 1911, 1 sheet, 250-27.

Further action on the merits is deferred pending compliance with the requirement of division.

*E. D. B...*  
Examiner, Div. 16.

240



1972

Case 36



PAPER NO 5  
AMENDMENT *A*  
*Oath*

UNITED STATES PATENT OFFICE.

Division 16 High 112

*Enter 5-18*

In re application of

HAROLD C. ARNOLD

Subject

Serial No. 285,527

VACUUM TUBE AMPLIFIERS

Filed March 28, 1919.

SEP 1 1920

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of September 24, 1919, please amend the above entitled application as follows:

- ✓ Page 2, line 9, change "12" to --12--.
- ✓ Page 3, line 3, change "35" to --36--.
- ✓ Cancel claims 15 to 19 inclusive.
- ✓ Add the following claim:

*A'*

*Pr B*

15. The combination with a circuit having high impedance, of a transformer for impressing electromotive force upon said circuit and a potentiometer arrangement for connecting the secondary of said transformer to said circuit--.

REMARKS

Claims 15 to 19 have been cancelled in response to the requirement for division.

New claim 15 is along the lines of claims 1 to 14 which have been retained. Action on the merits of these claims is respectively requested.

973

(Serial No. 225,527)

-2-

A new oath appropriate to a divisional application  
is filed herewith.

Respectfully,

HAROLD D. ARNOLD

By W. Beatty  
Attorney

463 West Street,

New York Aug 28, 1920.

HAN:PS





HAROLD DEFOREST ARNOLD

Serial No. 335,857

Filed March 30, 1910.

✓ # 5  
Subject;

Vacuum Tube Amplifiers

Q A T H



County of New York }

ss.

State of New York }

HAROLD DEFOREST ARNOLD, being duly sworn, deposes and says that he is the applicant in the above entitled application, that he is a citizen of the United States and resident of Maplewood, in the County of Essex, and State of New Jersey, and that he verily believes himself to be the original, first and sole inventor of the improvement in VACUUM TUBE AMPLIFIERS, described and claimed in said application; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the application of which this is a division, or in public use or on sale in the United States for more than two years prior to the application of which this is a division; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representative or assigns more than twelve months prior to the application of which this is a division; that no application for patent on said improvement has been filed by him or his legal representative or assigns in any country foreign to the United States prior to the filing date of said application of which this is a division; that the subject-matter claimed herein was a part of his invention disclosed in said original application was invented before he

(Serial No. 285,287)

-2-

filed said original application and has not been abandoned.

Harold Edward Smith

Sworn to and subscribed before me

this 30<sup>th</sup> day of August, 1920.

Jacob F. Gilbert  
Notary Public  
My Comm. Expires 30  
Sept. 1921  
Comm. No. 1000



976  
No. 16 Form 112  
Address only  
The Commissioner of Patents,  
Washington, D. C.,  
and not any other office.

LDG - app

Paper No. 6  
All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Feb. 24, 1921

Mr. John G. Roberts,

463 West St.,

New York, N. Y.

U.S. PATENT OFFICE  
FEB 24 1921  
MAILED

Please find below a communication from the EXAMINER in charge of the application of  
Harold D. Arnold, Ser. #285,857, filed March 25, 1919.

Vacuum Tube Amplifiers.

M. H. COULSTON

Acting Commissioner of Patents

This action is responsive to amendment filed  
August 31, 1920.

Claim 1 is rejected as pointing out nothing patent-  
able over LANGMUIR or CAMPBELL of record, attention being called  
to adjustable rheostats 22, 10 in Figs. 2 and 10 of the respec-  
tive references.

Claim 3 is rejected directly on CAMPBELL, and no in-  
vention is conceded in making the tap on resistance 10 adjustable.

Claim 4 is rejected as being met by LANGMUIR of record.

In claim 8, line 4, should not "inductively" be in-  
serted before "connected" to render the claim strictly descrip-  
tive.

In claim 11, it is not apparent how "maintaining the  
impedance . . . substantially constant" reads on applicant's  
disclosure. Furthermore, what element is intended to be desig-  
nated by "amplifying current"?

Claim 15 is rejected on the BRITISH patent cited,  
noting particularly the adjustable potentiometer arrangement I  
shunted across the secondary of transformer H in Figs. 2 and 3  
thereof.

Ser. 288,857 - 32.

All other claims appear allowable.

Inasmuch as this case has an effective filing date of more than five years, it comes within the provisions of Commissioner's Order 2210, 216 O.G. 1, concerning long pending applications. Applicant is urged to make a prompt reply placing the case in condition for final adjudication before the examiner.

*A. O. Backus*

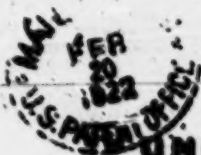
Exr., Div. 16.

6/17



978

Case 36

PAPER NO. 9  
AMENDMENT. B

## UNITED STATES PATENT OFFICE. Yaffelt

Division 16 Room 112

4270

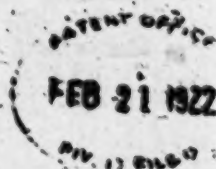
In re application of  
BAROED D. ARNOLD

Subject.

VACUUM TUBE AMPLIFIERS

Serial No. 885,857

Filed March 28, 1919

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir

In response to the Office actions of February 24, 1921 and March 30, 1921, please accept the above entitled application as indicated below:

In the preamble, cancel "VACUUM TUBE" and substitute --ELECTRON DISCHARGE--.

Page 2, lines 1 to 4, change "vacuum tube amplifiers" to --electron discharge devices--;

lines 5 to 6, change "a vacuum tube" to --an electron discharge--;

line 13, change "a vacuum" to --an electron discharge--.

Claim 1, line 1, change "vacuum tube" to --an electron discharge--, after "repeater" insert --comprising two electrodes--;

line 2, before "electric" insert --alternating current--;

line 3, cancel "a".

Cancel lines 4 to 7 and substitute:

--and means for effectively connecting said electrodes across an adjustable amount of said impedance.--

B  
Per C

4/18

(Serial No. 225,957)

--2.

✓ Claim 3, line 1, change "a vacuum" to --an electron discharge--; cancel "repeater";

✓ line 3, change "current through" to --voltage across--;

✓ line 4, cancel "a connection from said cir-".

✓ Cancel lines 5 to 7 and substitute:

--and means for effectively connecting said electrodes across an adjustable amount of said impedance.--

✓ Claim 4, line 1, change "A vacuum tube" to --an electron discharge--; and change "a vacuum" to --an electron discharge--;

✓ line 4, before "connecting" insert --effectively--.

✓ Claim 8, line 4, before "connected" insert --effectively--.

✓ Claim 11, lines 3 to 4, cancel "maintaining the impedance opposed to said amplifying current substantially constant,";

✓ line 5, cancel the period and substitute: while the impedance opposed to said alternating current remains substantially constant.

✓ Claim 12, line 1, change "a vacuum tube" to --an electron discharge--.

✓ Cancel claim 13.

### R E M A R K S

Claim 1 has been so amended that it patentably distinguishes from Languir, as does claim 3, by the limitation to a system in which an alternating emf is impressed on the impedance. Moreover, since Languir is a copending patent and the invention set forth in the claim obviously is not identical with any invention disclosed in the patent, it is thought that the claim is not properly rejectable on the patent.



(Serial No. 235,657)

--3.

This copending patent can not sustain a rejection on the ground of anticipation, and substantial identity of invention would be necessary to sustain a rejection on the ground of priority. (Ex parte Thomas, 251, 08 839)

Regarding the rejection of claims 1 and 3 on Campbell, that patent fails to give any suggestion whatever of adjusting the point of connection of the grid or filament lead along the resistance, and it is clear that Campbell had no more idea of varying the grid potential in a manner that would maintain the impedance presented to the source constant than had any one who used a vacuum tube amplifier. Further, it is thought that because of evident lack of identity of disclosure the copending Campbell patent is not properly citable against these claims.

*Hammond  
and  
Hammond  
states nothing  
over copending  
patent must  
be involved*

Moreover, it is believed that the applicant's affidavit presented herewith is competent to dispose of the Langmuir and Campbell patents with respect to claims 1 and 3 and also with respect to claim 4.

Although claims 1, 3 and 4 have been changed in some respects, the changes appear to be of such nature as not to disturb the patentability of the claims over the references other than Campbell and Langmuir; and moreover, the affidavit mentioned above carries the applicant's date back of all of these other references, except Van Nieuwen and Chambers.

Further, Meissner, DeForest, and Logwood are copending patents, and therefore would not be competent to sustain a rejection on the ground of anticipation.

It is thought that the amendments directed above to claims 9 and 11 render these claims adequately descriptive and clear, and put them in the condition in which the Examiner apparently believed that they would be allowable.

(Serial No. 205,657)

The amendment directed above to allowed claim, 12 does not disturb the patentability of the claim over the references.

Former claim 10, which was rejected, has been cancelled.

Reconsideration and allowance of the application are requested.

Respectfully,

HAROLD D. ARNOLD,

By John L. Lawrence  
Attorney.

463 West Street,

New York, Jul 18, 1922.

ELL:BP



## UNITED STATES PATENT OFFICE

MAIL ROOM  
FEB 28 1922  
U.S. PATENT OFFICE

In re application of

HAROLD D. ARNOLD

Serial No. 285,657

Filed March 28, 1919

Subject:

VACUUM TUBE AMPLIFIERS.

State of New York

County of New York

ss.

FEB 27 1922

## A P P E A R A N C E

HAROLD D. ARNOLD, being duly sworn deposes and says that he is the applicant in the application identified above; that the circuit shown on the attached print marked Exhibit A, represents a vacuum tube amplifier circuit which was set up and tested under his direction prior to February 5, 1914, in the research laboratory of the Western Electric Company, at 465 West Street, New York City, New York; that in this circuit a resistance was connected across a source of alternating potential difference and the grid and filament of the vacuum tube were effectively connected across an adjustable amount of said resistance; that currents of a frequency within the voice range were sent through said resistance and the voltage impressed across the input electrodes of the vacuum tube was varied by changing the adjustable connection between said input electrodes and said resistance to vary the amount of said resistance across which said input electrodes were connected; that said currents were amplified in a satisfactory manner; that said print is a copy of a drawing which was made prior to February 5, 1914; that he does not know and does not believe that the invention has been in public use or on sale in this country or patented or described in any printed publication in this or any foreign country more than two years prior to his original application of which this is a division; and that he has never abandoned the invention.

*Harold D. Arnold*

Sworn to and subscribed before

me this 1st day of January, 1922.

*Edward J. Connelley*  
Notary Public.

Notary Public, General County  
Edward J. Connelley, Clerk of the Court  
Residence 100 West 10th Street  
City of New York, N.Y.  
Commission Expires March 28, 1922

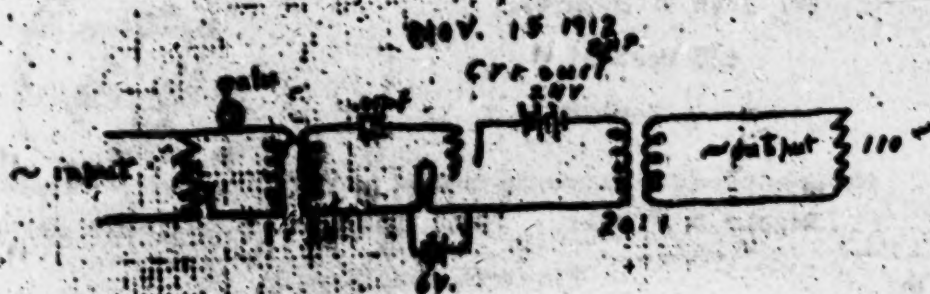
H.L.M.

Output thru 110" in Series with Secondary Transformer

Arnold Transformer used

Plate Voltage = 250

Filament I & II .35 amp.



Reapplication of  
Harold D Arnold  
Serial No. 285857  
Filed March 28, 1919

Exhibit A



No. 16 Date 112  
 Address only  
 The Commissioner of Patents  
 Washington, D. C.

HHD: LEE

Page No. 10  
 All communications respecting this  
 application should give the serial number,  
 date of filing, title of invention, and  
 name of the applicant.

DEPARTMENT OF THE INTERIOR  
 UNITED STATES PATENT OFFICE

WASHINGTON

Jan. 19, 1923

Mr. John G. Roberts,  
 463 West St.,  
 New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of  
 Harold D. Arnold, Ser. #235,857, filed March 28, 1919.  
 Electron Discharge.

Thomas E. Robertson  
 Commissioner of Patents.

This action is responsive to amendment filed  
 Feb. 20, 1922.

Record is made of

RE FOREST, 979,276, Dec. 20, 1910, 250-18;  
 RE FOREST, 1,375,447, Apr. 19, 1921, 179-100.2.

Claims 1, 3, 4, 7 and 8 are rejected as defining  
 nothing patentable over RE FOREST, 1,375,447, Fig. 4 of  
 which discloses the plate circuit of tube 52 as constituting  
 an adjustable resistance connected between electrodes 65,  
 66 of tube 52. In claim 7, line 2, should not affectively  
 be inserted after "resistance"; otherwise this claim appears  
 to be misdescriptive. Claims 1, 3 and 4 are further rejected  
 on the disclosure of Fig. 5 in RE FOREST, 979,276, the appli-  
 cation of which appears obvious.

All other claims appear allowable.

In view of the affidavit offered under Rule 75,  
 the CAMPBELL and LANGMUIR patents are withdrawn,  
 the subject matter of  
 In view of the long pendency of this case, appli-  
 cant should respond promptly.

*[Signature]*  
 Exr., Div. 13.

*11/17*

985

MAIL-ROOM  
OCT 15 1923  
U.S. PATENT OFFICE

Case No.

PAPER NO. 102  
AMENDMENT C

## UNITED STATES PATENT OFFICE.

Division 16 Room 112

4275

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 286,857

ELECTRON DISCHARGE AMPLIFIERS

Filed March 28, 1919

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of January 19, 1923,  
amend as indicated below:

Rewrite claims 1, 3 and 4 as follows:

C<sup>1</sup>

1. In combination, an electron discharge relay comprising an anode, a cathode and a control electrode, a circuit containing a source of alternating current electric impulses to be relayed, an impedance in shunt to said source, and means comprising a contact movable along said impedance for effectively connecting said control electrode and said cathode across an adjustable proportion of the whole of said impedance.

C<sup>2</sup>

3. In combination, an electron discharge relay having an anode, a cathode and a control electrode, a circuit containing an impedance, means for producing alternating voltage across the whole of said impedance, and means comprising a contact movable along said impedance for



~~Serial No. 2, 227 - 2~~

effectively connecting said cathode and control electrodes across an adjustable proportion of the whole of said impedance.

4. The combination of an incoming line, an amplifier having a cathode and an anode, means for supplying a space current between said electrodes, said amplifier having a grid electrode for controlling such space current, means for making said grid negative with respect to said cathode, and means between said line and the input electrodes for making the impedance of said amplifier as seen from said line substantially of a constant value, said last mentioned means comprising a potentiometer arrangement including an impedance and a contact movable along said impedance for varying the voltage supplied to said input electrodes.

✓ Claim 7, line 1, after the comma insert "two amplifying stages each including an electron discharge amplifier,"

line 2, before "stages" insert "said";

line 3, after "resistance" insert "effectively";

line 4, cancel "connection from an adjustable point on said"

and substitute "contact movable along said resistance and

connected"; line 5, cancel "resistance".

✓ Claim 8, line 3, cancel "connection from an adjustable point" and substitute "contact movable along said resistance and connected"; line 7, cancel "on said resistance".

63/26

Add the following claim:

C 4  
-15. The combination of an incoming line, an electron discharge relay of the three-electrode type, a transformer coupling said line to said relay, one coil of said transformer being inductively connected to the input electrodes of said relay, and a potentiometer arrangement in shunt to one of the coils of said transformer, said potentiometer arrangement comprising an impedance and a contact movable along said impedance for varying the voltage applied to said input electrodes without materially varying the impedance facing said line.

REMARKS

The Examiner's suggestion that "effectively" be inserted after "resistance" in line 2 of claim 7 has been followed although it seems clear that since the resistance is inductively connected in the output circuit of one amplifying unit it is connected in the output circuit of that unit. Being in that circuit it is, of course, also effectively in that circuit.

The applicant, of course, has no desire to cover circuits such as those shown in the de Forest patents cited in the last Office action. Claims 1, 3 and 4 are each adequately distinguished from de Forest 979,276 wherein there is no three-electrode electron discharge relay, amplifier or repeater, as called for in each of these claims. De Forest made no attempt to solve the applicant's problem of varying the relaying or amplifying effect of a vacuum tube relay without materially varying the impedance facing the source, and the patent, of course, discloses no solution such as that

23/27



Serial No. 235,857 - 4.

expressed in these claims. Moreover, these three claims clearly distinguish patentably from de Forest 1,575,447 wherein there is no contact movable along an impedance for connecting the input electrodes of the relay across an adjustable proportion of the whole of the impedance, or for varying the voltage supply to the input electrodes of the relay without materially changing the impedance facing the line.

Regarding the rejection of claim 7 on de Forest 1,575,447, this claim now specifies a resistance in a coupling between two stages, in addition to the two amplifying stages, each of which includes an electron discharge amplifier. Moreover, this claim now recites a contact movable along the resistance and connected to an electrode of the second amplifying unit, which is a structure widely different from anything found in the patent.

Claim 8, as amended, is believed to be patentable over de Forest No. 1,575,447, for the reason given above in connection with claim 7.

The new claim 13 is patentable over the references of record and also over the other claims in the case by virtue of the limitation to the potentiometer arrangement in shunt to one of the coils of the transformer coupling the line to the relay. This claim is similar to claim 2 of applicant's patent 1,428,880, March 18, 1923, Thermionic Amplifier Circuit, but is patentable moreover since the potentiometer arrangement enables the voltage applied to the input electrodes of the relay to be varied without changing the impedance facing the source.

63/48

Serial No. 220,007 - B.

Recommendation and allowance of the application  
are requested.

Respectfully,

HAROLD D. ARNOLD

*[Signature]*  
Attorney

405 West Street,  
New York, SEPT 13 1950, 1950.

HL:AO

63/29



990

Page 26

#13

## UNITED STATES PATENT OFFICE

Division 16, Room 112

In re application of

HAROLD D. ARNOLD

Serial No. 355,557

Filed March 25, 1919

Subject:

ELECTRON DISCHARGE AMPLIFIERS

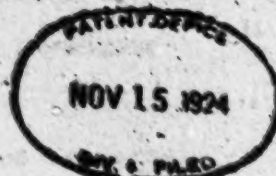
SUPPLEMENTAL OATH

NEW YORK

State of

County of

NEW YORK

SS.:  
BY: & FILED

HAROLD D. ARNOLD, whose application for letters patent for an improvement in ELECTRON DISCHARGE AMPLIFIERS, Serial No. 355,557, was filed in the United States Patent Office on or about the sixth day of March, 1919, division of original application Serial No. 43,575, filed September 3, 1916, being duly sworn, deposes and says that the subject matter of said application 355,557 as amended August 31, 1920, February 20, 1922, and October 15, 1923, including claims 1 to 10,

was part of his invention, was invented before he filed his original application, above identified, for such invention, was not known or used before his invention, was not patented or comprised in a printed publication in any country more than one year before his original application, was not patented in a foreign country on an application filed by himself or his legal representatives or assigns more than twelve months before his original application, was not in public use or on sale in this country for more than two years before the date of his original application, and has not been abandoned.

*Harold D. Arnold*

Subscribed and sworn to before me this

*8th* day of *November*, 1924.

*Charles J. Jones*  
Notary Public.

RECEIVED

U. S. PATENT OFFICE  
Division 16, Room 112  
Washington, D. C.  
Nov 15 1924

62/30





*Revised*

NUMBER (Series of 1915)

~~588283~~

1915

(EX'T'S. BUREAU) 705-3-7

251100 16

DIV. 16

PATENT No.

*Harold De Forest Arnold  
Asst. to Western Electric Company  
New York, N.Y. a Corp. of Illinois  
New York.*

*East Orange Mapewood*

County of *New Jersey*  
State of *New Jersey*  
Invention *Power Transmitting Amplifying Device*

Patent	Sept 3 1915	RENEWED	Sept 14 1922
Application	" " 1915		191
Specification	" " 1915		191
Drawing	" " 1915		191
Photo Copy	Sept 2 1921		191
First Div. Fee	Sept 3 1915	\$20	Sept 14 1922
" " Fee	" " 191		191
Appl. and complete	Sept 3 1915		Sept 14 1922

*705-3-7*  
*Feb 11 1923*  
*By Commissioner*  
*191*  
*191*  
*191*  
*191*

*De Witt L. Tamm*  
*John G. Roberts*  
*New York, N.Y.*  
*463 West 46th St.*  
*Power Transmitting Amplifying Device*  
*Class 29*  
*Address*  
*64/2*





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23

*F. W. 2*

24 TO ALL WHOM IT MAY CONCERN.

25       It is known that I, HAROLD DE FOREST ARNOLD, a  
26       citizen of the United States, residing at <sup>*Madison*</sup> ~~East Orange~~, in  
27       the County of Essex and State of New Jersey, have invented  
28       certain new and useful improvements <sup>*Power Limiting Compensating Device*</sup> in ~~radio communication~~;  
29       of which the following is a full, clear, concise, and exact  
30       description.

31       ~~This invention relates to receiving~~  
32       ~~systems for radio communication,~~

particularly to devices for limiting the electrical power  
 which may be transmitted to a receiving instrument in such a  
 system, and more particularly to devices in which such limit-  
 ing action is obtained by employing electric currents in an  
 evacuated vessel,

Its object is to provide rapidly responsive means  
 by which a definite upper limit is set upon the amount of power  
 which may be communicated to a receiving circuit or apparatus,  
 while amounts of power below said limit may be transmitted  
 without selective interference.

The ability to secure such limitation is desirable  
 in a radio receiving system for example, because foreign  
 disturbances, which in the wireless art are often of large  
 magnitude compared with that of the received signals, may be  
 reduced to a value not exceeding that of the signals, thus  
 securing higher intelligibility in reception.

~~The object of the invention may be accomplished by the apparatus herein~~  
~~This object is accomplished by making use of the fact~~

that unilaterally conducting elements, placed in opposition  
 in a circuit, limit the current which may flow in either  
 direction around that circuit, and in this respect this  
 invention is similar to that which forms the subject of my  
 previous application No. 227,050 for a Protection Device for  
 Electric Circuits, *granted January 15, 1916*  
 filed December 14, 1914. It differs from  
 that, however, in that additional elements are associated with  
 the unilateral devices, and elsewhere, to secure certain  
 improvements in operation, as explained later in this  
 specification, and also in that an amplifying effect is  
 obtained which makes this device particularly applicable in  
 radio communication.

In the preferred form of this device the unilateral  
 conductivity is secured by causing part of the circuit to lie  
 in the paths of thermionic currents between hot cathodes and



1 cold anodes, said thermionic currents being oppositely directed  
 2 with respect to said circuit. These thermionic currents are  
 3 caused to flow by impressing upon their limiting electrodes, in  
 4 multiple, an electromotive force operating through a high  
 5 impedance, said high impedance being potential in the operation  
 6 of the device for the purpose specified, by preventing unbalance  
 7 of currents in the two halves of the device. This high  
 8 impedance serves to differentiate this power limiting device  
 9 from the repeating device described in U. S. patent No.  
 10 1,120,202, to E.H. Colpitts for an Electric Wave Amplifier,  
 11 as will be apparent from the further explanation of its function  
 12 given later.

3  
 3 The nature of this invention will be more fully under-  
 4 stood by reference to the drawing, which represents a receiving  
 5 system for radio communication embodying this invention, and  
 6 in which 1 represents an elevated receiving conductor, 2 a  
 7 tuning inductance coil, 3 an adjustable condenser, and 4 an  
 8 adjustable resistance shunting the condenser. By means of the  
 9 coil 5, the tuned circuit 5, 6 is coupled to the antenna. The  
 10 terminals of the condenser 6 are connected to the input circuit  
 11 of the thermionic repeater 7, comprising heated filament 8,  
 12 grid 9 and plate 10. A battery 11 is preferably connected in the  
 13 input circuit to maintain the grid at a negative potential  
 14 with respect to the filament. 12 is a battery which serves to  
 15 heat the filament 8. The output circuit of repeater 7 contains  
 16 battery 15 and a choke coil 16, shunted by a condenser 14 so  
 17 afford a path for high frequency power, and the coils 13 and 17,  
 18 the latter having reversible inductive connection with coil 5,  
 19 the sense of its inductive action being controlled by reversing  
 20 switch 18. The purpose of coil 17 is to neutralize the coupling  
 21 between input and output circuits of the amplifier 7 and thus  
 22 prevent free oscillation or "singing". The coil 19, coupled

to 13, connects the above described amplifying circuit to the tuned circuit 19, 20. Across the terminals of condenser 29 is connected the input circuit of a <sup>detecting</sup> receiving device which comprises thermionic element 21, condenser 22 and resistance 23. The purpose of the <sup>combination of the</sup> condenser and high resistance in connection with thermionic element 21 is as follows: When a positive charge, for example, is forced upon the grid of element 21, this charge is neutralized by electrons from the filament. Then when, in the next alternation, a negative charge is forced to the grid by the incoming wave, this charge adds to that already present and produces a still larger negative charge upon the grid, since a negative charge cannot be neutralized by the electron stream. The condenser therefore aids in decreasing the average current in the output circuit. The grid must, however, be conductively connected to the incoming circuit, otherwise the accumulated negative charge would remain and prevent further operation. To provide for this, a high resistance leakage path is shunted around the condenser to allow a leak <sup>which is</sup> slow compared with the period of high frequency currents, but still rapid enough to permit considerable leakage in a time comparable with the period of telephonic waves. The output circuit of this thermionic element is supplied with current by batteries 15 and 27, acting through choke coil 28 and resistance 25, condenser 24 serving as a high-frequency shunt, and condenser 26 to limit the direct current to the <sup>detecter</sup> rectifier circuit. 31 is an amplifier having a battery 30 in series with its grid and a resistance 29 across its input circuit. The output circuit of amplifier <sup>31</sup> 29 comprises a battery 34 and choke/35, both shunted by condenser 33 and a coil 32. Coil 36, coupled with 32, supplies power to resistance 37, across a portion of which is connected the input circuit of another amplifier 38, having a battery 39 in its grid circuit. The output circuit of amplifier 38 is supplied

1917



1 by battery 34 and contains choke coil 42 condenser 40 and coil  
2 41, whose functions are the same as those of the corresponding  
elements in the previous amplifier. It also contains condenser  
43 and coil 44. The apparatus to the right of 44 comprises the  
power-limiting device and the receiving circuit.

3 In this device coil 45 is coupled to coil 44. 46 is  
4 a resistance. 48, 49 and 53 are the filament, grid and plate,  
5 respectively, of a structure of the audion type, as are also  
6 50, 51, 52, respectively. 47 is a battery common to the input  
7 circuits of the two structures, which structures may be in the  
8 same vessel or in separate vessels. 54 is a transformer wind-  
9 ing connecting plates 52 and 53 and having a connection brought  
10 out at its middle point. The secondary winding 55 of this  
11 transformer leads to a receiving instrument 56, preferably  
12 through the condensers 59.

13 Current is supplied to the output circuits of the  
14 last mentioned structures of the audion type by battery 65  
15 connected through coil 57, and the variable <sup>high</sup> resistance 58 to  
16 the middle point of coil 54 and to the common point of the two  
17 filaments 48 and 50. The receiving set is grounded at the  
18 points 60, 61, 62, 63 and 64.

19 The operation of this system is as follows: Power  
20 received by the antenna is transferred to the circuit 5, 6,  
21 augmented by amplifier 7, communicated to circuit 19, 20,  
22 transformed into low frequency form by <sup>detection</sup> rectification in element  
23 21, augmented by amplifiers 31 and 38, and passed to the  
24 receiving instrument through the power limiting device whose  
25 operation will now be explained.

26 The thermionic repeater being unilaterally conducting,  
27 the repeater element 48, 49, 53 can transmit <sup>positive</sup> current due to  
28 battery 64, only in the direction from 53 to 48. Also, element  
29 50, 51, 52 can transmit <sup>positive</sup> direct current only in the direction

1 from 52 to 50. If these currents are approximately equal, it  
 2 follows that the maximum variation in current around the  
 3 circuit 48, <sup>53</sup>54, 52, 50 can never exceed the magnitude of the  
 4 normal current in either element, provided none of this varied  
 5 ~~current can pass through the battery 65, which is common to the two thermionic elements~~  
 6 ~~age, choke coil 57 is used.~~

7 The variations in the normal currents in the winding  
 8 55, which variations constitute the signals to be received, are  
 9 produced in the usual way by the action of the grids 49 and  
 10 51, across which the signal voltage is impressed, so that it is  
 11 obvious that an impressed voltage of large value, tending to  
 12 produce a large variation of current in the power limiting  
 13 device, cannot cause an alternating or varying current in wind-  
 14 ing 55 larger than the normal space current of the elements.  
 15 This normal space current is adjusted until its value is just  
 16 greater than the amplitude of the signals to be received.

17 The resistance <sup>58</sup>55 prevents serious unbalance of  
 18 currents in the two halves of winding <sup>54</sup>55, when a large electro-  
 19 motive force is impressed, by lowering the effective potential  
 20 difference between plate and filament by the amount of the  
 21 voltage drop in the said resistance, and consequently decreasing  
 22 the current which can flow in the output circuit of either  
 23 repeater element, this effect being a fundamental one in the  
 24 operation of the thermionic repeater.

(30)



## WHAT IS CLAIMED IS:

1. A receiving system for radio communication comprising an antenna, a tuned receiving circuit connected therewith, means for amplifying the power of waves communicated to said tuned circuit, means for <sup>detecting</sup> ~~rectifying~~ said waves of amplified power, means for <sup>detecting</sup> ~~rectifying~~ said ~~rectified~~ waves, translating means responsive to said <sup>detecting</sup> ~~rectified~~ waves, and means including thermionic elements for limiting the power transmitted by said waves to said translating device.

2. In combination with a source of power, a power limiting device comprising <sup>an antenna</sup> ~~a thermionic repeater~~ with divided input and divided output circuits, a connection of said input circuit to said source of power, a high impedance path containing a source of electromotive force and connected between the points of division of said divided circuits, a receiving device and transformer windings for connecting said output circuit to said receiving device.

3. A receiving system for radio communication comprising an antenna, a receiving circuit connected therewith, means for amplifying the power of waves communicated to said circuit, means for <sup>detecting</sup> ~~rectifying~~ said amplified waves, means for amplifying said <sup>detecting</sup> ~~rectified~~ waves, translating means responsive to said <sup>detecting</sup> ~~rectified~~ waves, and a power limiting device comprising a thermionic repeater with divided input and divided output circuits, a high impedance path containing a source of electromotive force connected in the output circuit of said repeater and transformer windings for connecting said output circuit to said translating means.

4. In a power limiting device, the combination of <sup>a plurality of antennas</sup> ~~unilaterally conducting thermionic elements~~ connected in

Per A  
A  
A

Instant C5

A  
A  
A

Instant C6

~~any path in it~~  
 opposition in a circuit, a high impedance path and a source of constant electromotive force in said path, said elements being supplied with current in multiple through said path, auxiliary electrodes for varying said currents in response to an impressed voltage, and a receiving circuit and means for communicating variations in said currents to said receiving circuit.

*Per A*  
*Sub 8*  
*Q2*  
 5. The combination with a receiving system for radio telegraphy or telephony, of a power limiting device comprising unilaterally conducting thermionic elements connected in opposition in a circuit, a high impedance path and means for providing flow of currents through said elements in said path, auxiliary electrodes for varying said currents, a receiving circuit, and means for communicating variations in said currents to said receiving circuit.

*Insert A 2*



In Witness Whereof, I, \_\_\_\_\_, hereto subscribe my  
 name this 31<sup>st</sup> day of August A. D., 1915.

WITNESSES:

*Harold DeForest Arnold*  
*" " " "*

State of New York } ss.  
 COUNTY OF New York

HAROLD DEFOREST ARNOLD

\_\_\_\_\_, the above named petitioner,  
 being duly sworn, deposes and says that he is a \_\_\_\_\_ citizen  
 of the United States, and resident of \_\_\_\_\_ East Orange \_\_\_\_\_ in the  
 County of \_\_\_\_\_ Essex \_\_\_\_\_ and State of \_\_\_\_\_ New Jersey,  
 and that he \_\_\_\_\_ verily believes himself \_\_\_\_\_ to be the  
 original, first, and sole \_\_\_\_\_ inventor of the improvement in \_\_\_\_\_

RADIO COMMUNICATION

described and claimed in the annexed specification; that he \_\_\_\_\_ does not  
 know and does not believe that the same was ever known or used before  
 his \_\_\_\_\_ invention or discovery thereof; or patented or described in any  
 printed publication in the United States of America or any foreign country  
 before his \_\_\_\_\_ invention or discovery thereof or more than two years prior  
 to this application; or in public use or on sale in the United States for more  
 than two years prior to this application and that no application for foreign  
 patent has been filed by him \_\_\_\_\_ or his \_\_\_\_\_ legal representatives or  
 assigns in any foreign country.

*Harold DeForest Arnold*

Sworn to and subscribed before me  
 this 31<sup>st</sup> day of August 1915

*Robert Williams*

Notary Public.

NOTARY PUBLIC  
 NEW YORK COUNTY  
 NEW YORK CITY

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

1003

Jan. 15, 1916.

Mr. John G. Roberts,

443 West Street,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 48,873, filed Sept. 3, 1915.

Radio Communication.

*Thomas Ewing*  
Commissioner of Patents.

This application has been examined.

Page 4, line 27, "39" should be 31.Page 5, line 31, "53" and "48" should be trans-  
posed.Page 6, line 1, "52" and "50" should be trans-  
posed.

Page 6, line 17, "53" should be 58.

Claim 1 is substantially identical in scope as  
claims in copending application 48,005. A proper  
line of division should be maintained between the  
two cases.

Claims 2, 4 and 5 are each rejected on Colpitts,  
1,137,384, Apr. 27, 1915, 179 - 171. The double  
audion arrangement shown in Figure 4, e. g., would  
limit the power passing therethrough inasmuch as the  
current in the output circuit is produced solely  
by the battery 10 and is therefore limited in amount  
to the capacity of this battery. If the effective  
resistance of the audions could be reduced to zero  
by the incoming waves the current in the output cir-  
cuit would reach its maximum value which would be



48,873 -- 2.

limited by the resistance of the output circuit.

The input circuit is divided into branches 16 - 7a - 13a - 26 and 16 - 7b - 13b - 26, e. g., while the output is divided into two paths 10 - 7a - 2a - 11 and 10 - 7b - 2b - 11. The term "high impedance" is relative and therefore indefinite. The impedance 11 in the branched output of the reference is relatively high.

Claim 3 is allowed.

*W. A. Kimball*  
Examiner, Division XVI.

CS

1005

PAPER NO 3  
AMENDMENTUNITED STATES PATENT OFFICE  
DIVISION 16 Room 109

A-252

In re application of

Harold D. Arnold

Serial No. 48,873

Filed September 3, 1915

Radio Communication.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

is in reply to the Office action of January 13, 1916.

It is respectfully requested that the above entitled application be amended as follows:

✓ Page 4, line 27, change "29" to --51--.

✓ Page 6, line 17, cancel "53" and substitute --58--.

✓ Line 18, same page, change "55" to --54--.

Substitute --detecting-- for "rectifying" in line 3, page 4.

✓ Page 5, line 25, change "rectification" to --detection--.

✓ Page 5, line 30, insert --positive-- before "current" Line 32, before "direct" add --positive--.

✓ Add the following at the bottom of page 6:

--Owing to the fact that the vacuum tube repeaters can only transmit current in one direction, it is impossible to do more by any impulse than to decrease the current in one vacuum tube repeater to zero. The current in the other tends to increase



48,873

Per C

according to the increase of potential on the grid.

On account of this rise of <sup>potential</sup> current the resistance of the tube decreases, and since the output circuit contains a very high resistance 58, the voltage across the tube decreases. The circuit is so arranged by adjusting the resistance 58 that the fall of potential finally becomes so great as to prevent the rise of current above a certain amount.

If this amount is made approximately equal to the current required to transmit the talk, the interfering sounds, due to accidental causes, cannot possibly be of greater intensity than the speech.--

Claims 1 and 3, line 4, cancel "rectifying" and substitute --detecting--; and in lines 5 and 6 of both claims change "rectified" to --detected--.

Claim 4, line 7, cancel "and" (first occurrence), and change "communicating" to the singular number.

Add the following claims:

--6. In a receiving system for radio signaling, a power limiting device comprising ~~a thermionic element~~ <sup>ES</sup> having input and output circuits, a source of current for said output circuit, and regulating means in the output circuit for preventing the current supplied by said source from exceeding a given value.

7. In a receiving system for radio signaling, a power limiting device comprising ~~a thermionic element~~ <sup>ES</sup>

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Inventor  
Per 11

B  
Inventor  
Per 11

42,873

having input and output circuits, a source of power for said output circuit, and means responsive to the current in said output circuit for controlling the potential applied from said source to said ~~thermionic element~~ <sup>anode conductive space</sup> whereby the rise of current in said output circuit is limited.

8. In a receiving system for radio signaling, a power limiting device comprising <sup>an anode electron discharge</sup> ~~a thermionic element~~ having input and output circuits, a source of current for said output circuit, and a resistance in said output circuit for limiting the rise of current in said output circuit.

9. In a receiving system for radio signaling, a power limiting device comprising <sup>an anode electron discharge</sup> ~~a thermionic element~~ having input and output circuits, a source of current for said output circuit, and a resistance serially connected with said source for limiting the rise of current in said output circuit.

10. A receiving system for radio communication comprising an antenna, a receiving circuit connected therewith, means for detecting the waves communicated to said circuit, translating means responsive to said detected waves, and a device for limiting the power transmitted by said waves to said translating means; said device comprising <sup>an anode electron discharge</sup> ~~a rectifier~~, a source of current therefor, and means for determining the intensity of the effect produced in said translating means by a signal wave of a certain intensity and for preventing waves of greater intensity from exceeding said effect.

11. In a power limiting device, the combination <sup>anode</sup> ~~of unilaterally conducting thermionic elements~~ <sup>connected</sup>



48,873

in opposition in a circuit, said elements having input and output circuits, means for supplying current to said output circuits, means for preventing ~~frequency~~ <sup>high frequency</sup> currents from passing through said supplying means, and means for regulating the maximum value of the current furnished by said supplying means.

12. In a combination with a source of power, a ~~power limiting device comprising a thermionic converter~~ <sup>electromotive force</sup> with divided input and divided output circuits, a connection of said input circuit to said source of power, a path connected between the points of division of said circuits; said path comprising a source of electromotive force, means for preventing ~~high frequency~~ <sup>high frequency</sup> currents from passing through said source, and means for regulating the maximum value of the current supplied from said source; a receiving device, and transformer windings for connecting said output circuit to said receiving device.

13. In combination with a source of power, a power ~~limiting device comprising a thermionic converter~~ <sup>electromotive force</sup> with divided input and divided output circuits, a connection of said input circuit to said source of power, a path connected between the points of division of said circuits; said path comprising a source of electromotive force, an impedance device for preventing ~~high frequency~~ <sup>high frequency</sup> currents from passing through said source, and a resistance for regulating the maximum value of the current supplied from said source; a receiving device, and transformer windings for connecting said output circuit to said receiving device.

B. J. Fuller

**REMARKS**

As to paragraphs 3 and 4, page 2 of the Office letter, the drawing shows plates 52 and 53 connected to the positive pole of battery 55, while filaments 50 and 48 are connected to its negative pole. Page 5, line 51, and page 6, line 1, describe that the current flows within the external circuit from the positive to the negative pole of battery. This is customarily considered to be the direction in which the current will flow as the positive pole indicates the pole of higher potential, and it is generally assumed that the current flows in an external circuit from a point of higher to a point of lower potential.

To differentiate from the direction of flow of the negative electron stream, the specification has been amended to show that the positive current is transmitted in the direction indicated.

Claim 1 is retained in this application, and a proper line of division will be maintained with the application to which the Examiner refers.

Reconsideration and allowance of claim 2 are respectfully requested. It is true, as the Examiner states, that the current in the tube circuit of the system shown in Fig. 4 of the patent 1,137,364 is limited by the capacity of the battery. But this limiting value is too high for practical purposes, and is reduced in the present case to a lower value by means of resistance 56.

The specification has been amended to bring out the fact that resistance 56 is adjusted so that the current cannot rise above a given value due to the IR drop in that resistance.



This limiting value of the current is made approximately equal to the current required to transmit talk. Then a static disturbance which may be many times as strong as the signal, cannot produce in the receiver an effect any greater than that produced by the signal.

The patent to Colpitts supra shows only the low impedance path provided by battery 10 between the points of division of the divided output circuit, whereas, Claim 2 recites a high impedance path containing a source of electromotive force connected between the points of division of said divided output circuit. This clearly differentiates from the patent to Colpitts which does not show impedance 11 connected between the points of division of said divided output circuit, and it is thought that on reconsideration the Examiner will find Claim 2 allowable.

It is noted that Claim 3 is allowable.

It is thought that Claim 4 should be allowed for the reasons noted in connection with Claim 2, and since the patent to Colpitts shows no high impedance path and a source of constant electromotive force in said path, said thermionic elements being supplied with current in multiple through said path. The thermionic elements in the patent to Colpitts are supplied in series through the halves of the impedance 11. The impedance 11 does not supply the elements in multiple. This difference should warrant the allowance of Claim 4.

Reconsideration and allowance of Claim 5 is requested for the reasons noted above, and furthermore, because the patent to Colpitts does not show a high impedance path and means for providing flow of current through said (thermionic) elements in said path. What the patent to Colpitts does show is "two high impedance paths and means for providing flow of currents through each of said elements in one of said paths".

48,873

Claim 5 recites a single high impedance path which carries currents to both the thermionic elements while the reference shows a high impedance path for each element. Since the applicant provides a single impedance path that performs the function of the two paths in the reference, it is thought that this claim should be allowed.

New claims have been added to bring out the function of the resistance 56 to limit the maximum value of the current. This function is described in the last paragraph of page 6, and has been amplified in the paragraph added to that page.

An attempt has been made to overcome the Examiner's criticisms and an early allowance of this case is respectfully solicited.

Respectfully,

HAROLD D. ARNOLD

By

*J. Roberts*  
Attorney.

463 West Street,

New York, Aug 31, 1916.

WED-44  
754



Div. 16 Room 109

The Commissioner of Patents,  
Washington, D. C.,  
and not any other office.

H.

Paper No. 4

All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Oct. 31, 1916.

Mr. John G. Roberts,

463 West Street,

New York, N. Y.

U. S. PATENT OFFICE  
OCT 31 1916  
MAILED

Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 48,875, filed Sept. 5, 1915.

Radio Communication.

Thomas Ewing  
Commissioner of Patents

This action is in response to amendment filed  
Sept. 1, 1916.

Upon reconsideration the rejection of claims  
3 and 4 upon Colpitts, 1,187,564, is withdrawn.

It is still considered that claim 5 is anticipated  
by the Colpitts disclosure in view of the fact that  
the claim does not set forth that the high impedance  
path may not include impedance 11, shown in Figure 4,  
of Colpitts, and consequently it does not distinguish  
from that reference.

Claims 2 and 4 to 12, inclusive, are rejected  
upon the subject-matter of the claims in the patent  
to Arnold, 1,188,270, Jan. 18, 1916, 250-35,1. It  
is considered that to allow such claims in the present  
application would amount to double patenting, inasmuch  
as the claims might have been presented in the prior  
application.

Claim 13 is also rejected upon the ground that  
it does not involve invention to supply a regulating  
resistance in any battery circuit.

Claims 1 and 3 appear allowable.

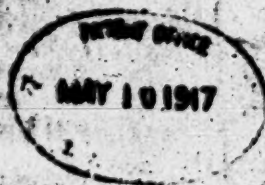
W. H. Kinnear  
Examiner, Division XVI.



UNITED STATES PATENT OFFICE  
Division 10 - Room 109

(B)  
In re application of  
Harold DeForest Arnold  
Serial No. 99,873  
Filed September 3, 1915

Radio Communication



COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

This amendment is in response to the Office action of October 31, 1916. Please amend as follows:

✓ Claim 3, line 2, cancel "a thermionic" and substitute --anode--; and change "repeater" to --repeaters--.

✓ Claim 4, line 2, cancel "unilaterally conducting thermionic" and substitute --a plurality of anodes--.

✓ Claims 6, 7, 8 and 9, line 2, change "a thermionic" to --an anode--.

✓ Claim 7, line 4, cancel "thermionic" and substitute --anode--.

✓ Claim 10, line 2, change "a repeater" to --an anode--.

✓ Claim 11, line 2, cancel "unilaterally conducting thermionic" and substitute --anode--.

✓ Claims 12 and 13, line 2, change "a thermionic repeater" to --anode repeaters--.



Cancel claim 5 and substitute the following:

-- 5. The combination of a receiving system comprising two <sup>said device</sup> ~~audions~~, each having an input circuit and an output circuit, <sup>and</sup> a portion of the similar circuits of <sup>device</sup> ~~said audions~~ being in common, a high impedance in the common portion of said circuits, ~~and signal translating means associated with said audions.~~

Add the following claim:

-- 14. The combination of a receiving system <sup>electron discharge device each including an impedance varying element</sup> comprising two ~~audions~~, each having an input circuit and an output circuit, a portion of said output circuits being in common, <sup>and</sup> a high impedance in the common portion of said output circuits, ~~and signal translating means associated with said audions.~~

*6'0 follows*

REMARKS:

Claims 2 and 4 to 13, inclusive, have been restricted to "audion" systems which takes these claims away from the valve system shown in the patent to Arnold, 1,168,270. New claims 5 and 14 are also limited to "audion" systems.

Furthermore, the present claim 5 is believed to differentiate from the patent to Colpitts, 1,137,384, of record as this claim recites that the high impedance is included in that portion of the similar circuits of the audions which is common to these audions. In Fig. 4 of this patent to Colpitts only the battery

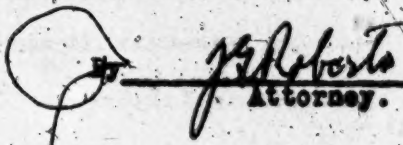
16 is included in the common portion of the input circuits of the two audions and only battery 10 is included in the common portion of the output circuits. This patent to Colpitts does not show a high impedance in either the common portion of the input circuits or in the common portions of the output circuits. The arrangement defined by claim 5 enables applicant to use an impedance of half the size shown in the patent, since the path for both audions passes through a single impedance, whereas, in the patent, two impedances are in effect provided, one for each audion.

Claim 14 is more specific than claim 5 in that it recites that the high impedance is included in the common portion of the "output" circuits of the two audions.

It is thought that the Examiner will find the claims in their present form to be allowable.

Respectfully,

HAROLD DeFOREST ARNOLD,

   
Attorney.

463 West Street,

New York, May 5, 1917.

463-AA  
H.A.



16 Room 109  
The Commissioner of Patents  
Washington, D. C.  
and salary fixed by law.

Patent No. \_\_\_\_\_  
An acknowledgment of the receipt of the  
application should give the serial number,  
date of filing, title of the invention,  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

July 5, 1917.

Mr. John G. Roberts,

465 West Street,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 48,875, filed Sept. 2, 1915,

Radio Communication.

*Thomas Ewing*  
Commissioner of Patents.

This action is in response to amendment filed  
May 9, 1917.

Page 2, line 22, the date of the patent re-  
sulting from application No. 877,056 should be sup-  
plied.

Page 5, lines 10 and 11 must be fully illus-  
trated as to both modifications, or canceled; line  
14, the receiver 66 must be illustrated by standard  
diagram or labeled.

Claims 2 and 4 to 14, inclusive, are rejected  
upon the subject-matter of the claims in the patent  
to Arnold, 1,168,270, of record. The term "audion"  
does not distinguish from the thermionic elements in  
the reference Arnold for the reason that this term  
has been used to loosely define all electron dis-  
charge devices comprising a heated filament as one  
electrode and cannot be considered as limiting the  
claims to a three electrode element. Note, for ex-  
ample, pages 212-214, inclusive, of "Principles of  
Electric Wave Telegraphy", by Pierce, 1920, McGraw-

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Bill Book No.

Arnold, 1,200,791, Oct. 10, 1916, 250-27, I.  
is made of record.

*W. A. Kinnear*  
Examiner, Division XVI.

*W. A. K.*



1018



Case 16

PAGE NO 7

AMENDMENT C

## UNITED STATES PATENT OFFICE.

Division 16 Room 102

A 262

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 48,873

Radio Communication

Filed September 3, 1915

JUN 14 1918

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of July 5, 1917,  
please amend the above entitled application as follows:

Page 1, line 28, change the title "RADIO COMMUN-  
ICATION" to --Power Limiting Amplifying Devices--; same  
page, cancel the last two lines and substitute therefor,

This invention relates to power limiting repeat-  
ing and amplifying devices, and especially to devices of  
this kind which are adapted to be used in radio communica-  
tion systems.

Page 2, line 1, cancel "particularly to devices";  
lines 4 and 5, cancel "employing electric currents in an  
evacuated vessel" and substitute therefor, --utilizing the  
properties of thermionic or equivalent discharge devices--;  
line 10, cancel "selective"; after line 16, insert the  
following paragraph:

In a general aspect, the object of this invention  
is to provide improved circuits and means for association  
with thermionic repeating devices. lines 17 and 18, can-  
cel "this object is accomplished by making use of the fact  
that", and substitute therefor, --The objects of the  
invention may be accomplished by the apparatus herein

(Serial No. 46,873)

disclosed wherein.--; line 22, cancel "previous application No. 877,056" and substitute therefor, --patent No. 1,168,270--; line 23, cancel "filed December 14, 1914." and substitute --granted January 18, 1916.--

Page 5, line 18, after "variable" insert --high--; line 20, after the period insert the following sentence:

Condenser 56 and choke coil 57 tend to prevent fluctuations of current from the source 65 from passing through the thermionic elements and coils 54.

Page 6, line 5, after "through" insert --that part of the circuit of --; same line, after "65" and before the period insert, --which is common to the two thermionic elements--; lines 5 and 6, cancel "to prevent such passage, choke coil 57 is used." and substitute therefor --To prevent any appreciable passage of variable current the high resistance 58 is used.--

In the insertion at the bottom of page 6, which is found in the amendment filed September 1, 1918, in line 7 thereof, change "current" to --potential--.

Claim 2, line 2, cancel "audion repeaters with" and substitute --electric discharge devices each including an impedance controlling element, said devices having--.

Claim 3, line 2, cancel "audion elements" and substitute --evacuated vessels each including a unilaterally conductive space, an impedance controlling element for said space, said spaces being--.

Claim 5, line 2, cancel "audions" and insert --electron discharge devices each including an impedance controlling element--; same line, after "each" insert --said device--; line 3, before "a" insert --and--; line 4, change "audions" to --devices--; line 6, change the comma to



(Serial No. 48,873)

a period and cancel "and signal translating means associated with said audions."

Claims 6 and 7, line 2, cancel "an audion element" and substitute --a conductive space, an impedance controlling element therefor, said device--.

Par C 10

Claim 7, line 6, cancel "audion element" and insert --conductive space--.

Claims 8 and 9, line 2, cancel "audion" and substitute --electron discharge--.

Claim 10, line 6, cancel "audion" and substitute --electron discharge device--.

Claim 11, line 2, cancel "audion elements" and substitute --electron discharge devices each including an impedance varying element--; lines 5 and 6, cancel "high frequency" and substitute --fluctuating--.

C 1

Claims 12 and 13, line 2, cancel "audion" and substitute --electron discharge--; line 7 of each, cancel "high frequency" and substitute --fluctuating--.

Claim 14, line 2, cancel "audions" and substitute --electron discharge devices each including an impedance varying element--; line 4, insert --and-- before "a"; line 5, change the comma to a period and cancel lines 6 and 7.

Add the following claims.

15. In combination, a plurality of electron-ic discharge devices, <sup>each</sup> one or more of said devices having an impedance varying element, a source of space current <sup>for said devices</sup>, and means tending to maintain the sum of the space currents through said devices constant.

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Par E.

(Serial No. 48,873)

16. In combination, a plurality of electrical circuits each of said circuits including a conductive space, ~~one or more elements for varying the impedance of one or more of said spaces respectively,~~ a current supply source for said circuits, and means associated therewith tending to keep the sum of the currents through said circuits constant.

17. An amplifier comprising two electrical discharge devices, input and output circuits therefor, said devices being symmetrically and oppositely disposed with respect to each of said circuits, space current paths for said devices, said paths having a common external portion of high impedance.

18. An amplifier comprising two electrical discharge devices, input and output circuits therefor, said devices being symmetrically and oppositely arranged with respect to each of said circuits, space current paths for said devices, a source of space current therefor, said paths having a common external portion, and means associated with said source for preventing fluctuating currents there-through.

19. An amplifier comprising two space discharge devices, input and output circuits therefor, said devices being symmetrically and oppositely arranged with respect to each of said circuits, space current paths for said devices, said paths having a common external portion and a resistance in said portion which is large as compared with

Per 10  
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Insert E-2



(Serial No. 48,873)

46  
the normal impedance of the conductive space of one of said devices.

20. A repeater comprising two electric discharge devices, each having a cathode, an anode and an impedance varying element, a connection between said impedance varying elements, a connection between said cathodes, a connection between said anodes, an electrical impedance in one of said connections, an electrical impedance in another of said connections, other connections from intermediate portions of each of said impedances to one of said first mentioned connections, one of said last named connections being provided with a source of current, and means tending to maintain a constant supply from said source.

21. In a repeater, two oppositely disposed electric discharge devices, impedance varying elements for said devices, means for causing one of said elements to increase the impedance of one of said devices, and the other of said elements to decrease the impedance of the other of said devices simultaneously, and means to cause the charges of current through said devices to be simultaneously substantially equal and opposite respectively when said repeater is repeating alternating current.

Sub E<sup>3</sup>  
22. In a signaling system, a power limiting device comprising an electron discharge device

E<sup>3</sup> follows  
64/32

(Serial No. 48,873)

*Per 10*

having input and output circuits, a source of space current for said output circuit, and a resistance in said output circuit of such value that signals will produce a desired change of current but impulses of greater intensity will produce no materially greater change.

*Sub E4*

*Per 10*

In a signaling system, a power limiting device comprising an electron discharge device having input and output circuits, a source of space current for said output circuit, and a resistance in said output circuit, said source and said resistance being of such values that incoming signal impulses will produce desired changes of current, but incoming impulses of greater strength will produce only negligibly large changes of current.--

*Inventor*

### REMARKS

In a separate communication it is requested that the various inductance coils in the drawings be changed so they will not be confused with resistances.

In view of the Examiner's suggestion that the term "anode" may be construed to include an evacuated vessel having only an anode and a cathode, claims 2, 4, 5, 6, 7, 11 and 14 have been amended to clearly differentiate from applicant's patent No. 1,168,270.

Claims 8 and 9 include a resistance in the output circuit for limiting the rise of current which is not disclosed in the Arnold patent.



(Serial No. 48,873)

Claim 10 includes a detector and numerous other elements of a receiving system not found in the patent.

Claims 12 and 13 define electron discharge repeaters which are not found in the Arnold patent.

It should be kept in mind that patent No. 1,168,270 was issued upon an application co-pending with the present application, and as the law is understood, it is believed that it is not a reference for any invention claimed in this case but the only requirement is that the subject matter claimed herein should constitute an invention which is divisible subject matter from that claimed in the patent. It is believed, moreover, that all the claims are new for combinations not found in the patent.

A number of amendments to the specification have been made with the intent to describe the construction and operation of the invention in clearer language and in greater detail. The function of the condenser 85 which is to eliminate impulses from the source 65 in case the source consists of a dynamo-electric machine or the like has been stated.

On reviewing the case, it has been thought that certain features of the invention were not protected as fully as desirable, hence a number of claims have been added with a view to accomplish this result.

All the added claims are believed to be so drawn as to be patentable over the prior art and to maintain a clear line of division between this application and the more generic patent No. 1,168,270. Claims 16 and 19 for

(Serial No. 48,873)

example, define an amplifier and the patent does not disclose an amplifier. It should be noted that the patent does not disclose a current limiting resistance, nor the elements of a receiving system, nor discharge devices which have a grid or impedance controlling element.

It is thought that the application is now in condition for allowance and such action is respectfully requested.

Respectfully,

HAROLD D. ARNOLD,

By W. Roberts  
Attorney

465 West Street,

New York, June 17, 1918.

783-1M



15 Room 115

ABS.

930

Paper No. 9

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

Address only  
in Communications or Patent  
Washington, D. C.  
and may be filed by mail.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Sept. 17, 1918.

John G. Roberts, Esq.,

920 Broadway,

New York, N.Y.

Received from the EXAMINER in charge of the application of  
Harold DeForest Arnold, Ser. No. 48,873, filed Sept. 3, 1915.

Power Limiting Amplifying Devices.

James S. Newton  
Commissioner of Patents

This action is in response to amendment filed  
June 15, 1918.

In the drawing the receiver 65 should be shown  
by the standard symbol for the telephone receiver or  
else labeled receiving instrument.

The following references are added to the references  
of record:-

SCHLORILCH et al.	1,087,892,	Feb. 17, 1914	(250-42);
DeF. ARNOLD,	1,114,845,	Oct. 27, 1914	(179-171)
COLVITTS,	1,128,392,	Feb. 16, 1915	(179-170)
ARNOLD et al.	1,231,964,	July 3, 1917	(250-20);
LANEYER,	1,275,625,	July 23, 1918	(171-97);

Farconi, British, 20,441 of 1910, (2 shts.) (250-20).

Claim 4, line 31, "including" should be enclosing, as  
the space is not a part of the vessel.

Claim 5 is not grammatically complete and should be  
revised.

In claims 4 and 7, a conductive space is an intangible  
element and cannot properly be claimed. See ex parte Davin,  
C. D. 1902, page 232.

Claims 8 and 9 are rejected as defining nothing

Ser. No. 48,873.

#2.

patentable over the patent to Arnold, 1,114,845.

Claims 15 and 16, the phrases "one or more" render these claims alternative. These two claims are met in the patent to Langmuir, cited, and are rejected. The inductance 3 is means for maintaining the sum of the space currents through 5 and 14 constant.

Claims 22 and 23 are rejected as defining nothing patentable over the patent to Arnold, 1,114,845, which meets these claims by giving proper values to the resistance 8.

The remaining claims are considered allowable.

As this application has been pending for more than three years applicant's response to this action should be prompt and of such nature to place the case in condition for final action. See Commissioner's order 2210, 216 O.G.1 concerning long pending applications.

H.S.M.

*R.W. Smith*  
Acting Examiner, Division 16.

1027



1028

MAIL ROOM  
JUN  
6  
1919  
U.S. PATENT OFFICE

Case 16

PAPER NO. 10  
AMENDMENT

## UNITED STATES PATENT OFFICE.

Division 16 Room 112

A 270

In re application of

Harold D. Arnold

Subject.

Serial No. 48,875.

Radio Communication

Filed September 3, 1916.

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of September 17, 1916, please amend the above entitled application as follows:

Cancel the insertion at the end of the specification (bottom of page 6) which was made in the amendment filed September 1, 1916, and substitute therefor the following:

Following to the fact that the vacuum tube repeaters can transmit current in one direction only, it is impossible to do more by any impulse than to decrease the current in one vacuum tube repeater to zero. The current in the other tends to increase in accordance with the increase of potential on the grid.

The total drop of potential in the output circuit is made up of two parts, that across the tube between the anode and cathode and that across the resistance 40.

If now the current is increased, not by increasing the electromotive force of the battery or source 45, but by increasing the potential difference

out  
before  
of June 9  
1919

Ad

28

See

between the cathode and the grid, the current through the resistance 59 increases. Since the output source 55 remains constant, it follows that the drop of potential across the tube decreases while that across the resistance 59 increases. A choking effect is thus produced by the resistance 59 with the result that, as the grid potential becomes greater, more and more current is diverted to the grid. A point is finally reached where no measurable increase in anode-cathode current is produced by increasing the grid potential. If the maximum amount of current is made approximately equal to the current required to transmit the talk, the interfering sounds, due to accidental causes, cannot possibly be of greater intensity than the speech.

Rewrite claims 4, 5, 7, 8, and 9 as follows:

10<sup>2</sup>

4-5. A receiving system comprising two electron discharge devices, each of said devices including an impedance controlling element, individual input circuits and individual output circuits for said devices, a portion of the similar circuits of said devices being in common, and a high impedance in the said common portion.

6. In a receiving system for radio signaling, a power limiting device comprising separated elements, an impedance controlling means for controlling the impedance of the space between said elements, said device having input and output circuits, a source of current for said output circuit, and regu-



Serial No. 48,873---5.

limiting means in the output circuit for causing the current supplied by said source to approach a maximum value as the input voltage is increased.

7. In a receiving system for radio signaling, a power limiting device comprising separated electrodes, an impedance controlling means for controlling the impedance between said electrodes, said device having input and output circuits, a source of power for said output circuit, and means responsive to the current in said output circuit for controlling the potential applied from said source across said electrodes whereby the rise of currents in said output circuit is limited.

8. In a receiving system for radio signaling, a power limiting device comprising an electron discharge element, an input circuit and an output circuit for said element, said output circuit having a portion which is traversed by fluctuating current passed by said element, and a high resistance in said portion.

9. In a receiving system for radio signaling a power limiting device comprising an electron discharge element, an input circuit and an output circuit having a portion which is traversed by fluctuating current passed by said element, a source of current for said output circuit, and a high resistance in said portion serially connected with said source for limiting the rise of current in said output circuit.

Claim 18, line 2, cancel "one or more" and insert

*as follows*

✓ Claim 16, line 3, cancel "one or more"; line 4, cancel "of one or more".

✓ Claim 22, line 5, after "resistance" insert --so located--; after "circuit" insert --and--.

✓ Claim 23, line 6, after "values" insert --and said --resistance being so located in said output circuit--.

Add the following claims:

23. A system for repeating alternating current comprising a plurality of electron discharge devices, an impedance varying element for one of said devices, a source of space currents for said devices, means tending to maintain the sum of the space currents through said devices constant, and means for utilizing the repeated alternating current.

24. A system for amplifying alternating or fluctuating current energy comprising two electrical discharge devices, input and output circuits therefor, said devices being symmetrically and oppositely disposed with respect to each of said circuits, and space current paths for said devices, said paths having a common portion external to said devices and of high impedance to currents of the frequencies to be amplified.

25. A receiving system comprising an electron discharge element, an input circuit and an output circuit for said element, said output circuit having a portion through which the fluctuating component of the current in said output circuit passes, said portion being of relatively high impedance to the fluctuating component.



Serial No. 48,873---5.

27. An amplifier comprising two electron discharge devices, an electron emitting cathode and an anode for said devices, space current circuits for said devices, said circuits having a common portion and individual portions, and a high impedance in said common portion.

*Par E*

28. In combination, a plurality of electron discharge devices, one of said devices having an impedance varying element, a source of space currents associated with said devices so as to constantly maintain an unidirectional potential across said devices, and means tending to maintain the sum of the space currents through said devices constant.

28-29. In combination, a source of current, a plurality of electron discharge devices having space current paths, said paths being similarly connected to said source, one of said devices having an impedance varying element, and means tending to maintain the sum of the space currents through said devices constant. *E. follows*

#### REMARKS

*Insert E.5-*

A revision of the theoretical explanation at the end of the specification has been made to make the disclosure more clear.

The Examiner's objection to the use of the word "including" in claim 4, line 8, is not well founded. The primary meaning of the word "including" as given in the Standard Dictionary is "to confine within something; hold

Serial No. 48,873---6.

as within an enclosure; enclose; contain".

Claims 5, 6 and 7 have been rewritten to correct informalities, but without substantial change of subject matter.

Claims 8, 9, 22 and 23 have been amended to distinguish from the patent to Arnold, 1,114,845. In that patent, it will be noted that the condenser 9 is in shunt to the resistance 8 and as pointed out in the specification, at lines 64 to 66, this condenser is of such value that the alternating or fluctuating component of the current passes therethrough. It will, therefore, be apparent that the patented arrangement could not function efficiently to limit alternating current energies of frequencies as high or higher than those which the device is adapted to repeat. Owing to the capacity of the condenser 9, a brief rise of current of large magnitude can take place. In the present arrangement, a high resistance or inductive impedance such as 58, prevents any such large increases of current. The patented arrangement was not intended to limit the alternating current but only to eliminate blue haze in case this abnormal condition occurred. When blue haze occurs, the output current assumes a permanently increased value until the blue haze is stopped. The present invention is operative to perform its intended function in case the vacuum tube is so highly exhausted that no blue haze will occur, even at the highest impressed potentials. While the present arrangement may perform the function of the patented arrangement, it is obvious that an additional and novel function is also performed. It is believed that amended claims 8, 9, 22 and 23 and added claim 26 definitely define the means which distinguish the present invention from applicant's prior patent 1,114,845.



Serial No. 48,873---7.

Claims 15 and 16 have been amended to remove informalities and to distinguish from the direct current transformer system of Langmuir's patent 1,275,526. Certain new claims to somewhat similar subject matter have been added and distinguish from this patent in various particulars. It will be noted that applicant's system differs in numerous fundamental respects from that of Langmuir, one of which is that while applicant desired small or negligible change of current through impedance 58, Langmuir's system will not function efficiently unless considerable changes of current take place in the inductance 3 as it is only by virtue of such changes that substantial amounts of energy can be stored in the inductance 3 and thence given out to circuit 12-13.

The Examiner's reference to Commissioner's order 2210 is noted and the utmost care consistent with obtaining adequate protection has been made to place the application in condition for final action.

It is believed that all the claims are patentable over each and every reference of record considered either singly or in combination and that the application is in condition for allowance, hence such action is requested.

Respectfully,

HAROLD D. ARNOLD,

BY J. S. Roberts

Attorney.

920 Broadway,

New York, New York June 4, 1919.

JWS-LM-UR

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

1035

The Commissioner of Patents,  
Washington, D. C.,  
and not any official by name.

LBG

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

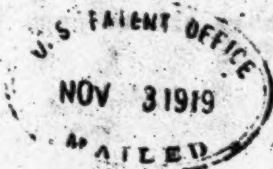
WASHINGTON

Nov. 3, 1919

Mr. John O. Roberts,

463 West St.,

New York, N.Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold D. Arnold, Ser. #48,873, filed Sept. 2, 1915.

Power Limiting Amplifying Devices.

*James I. Newton*  
Commissioner of Patents.

This action is in reply to amendment filed June 5, 1919.

Claims 15 and 16 are rejected on patent to Langmuir.

Either or both of Langmuir's devices 5, 14 might have a grid electrode without invention. It is common to use the three-electrode valve as a two-electrode valve if desired, merely leaving the grid unconnected. There are no elements set forth in these claims to indicate any cooperative relation whatever between the grids or impedance control elements and the remaining elements set forth in the claims.

Claims 22 and 23 are rejected on patent to Arnold, 1,114,845, of record. The amendments to these claims are merely functional statements, and all the structure set forth in the claims is found in the patent to Arnold. If applicant's device obtains a result not obtained by Arnold, it must be because of a different construction not found in Arnold, in which case the difference in <sup>the</sup> structure itself should be set forth in the claims.

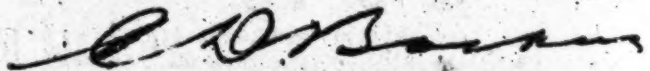
Claim 28 is rejected on Langmuir of record. The direct current source constantly maintains a unidirectional potential across both the devices 5 and 14 and the inductance 3 tends to maintain the ~~but~~ of the space currents constant.



Ser. #49,873.

As a clear issue has been reached in this case and the application has been pending for over four years, this action is made final. However, the examiner will admit any amendment which will enable him to pass the case for issue.

H.S.M.



Examiner, Div. 16.



1037

Case 16

PAPER NO 14  
AMENDMENT E

## UNITED STATES PATENT OFFICE.

Division 16 Room 112

In re application of

HAROLD D. ARNOLD

Subject.

Serial No. 48,873

Radio Communication

Filed September 3, 1918

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

9761 - PAON

Sir:

In response to the Office action of November 3, 1919,  
please amend the above-entitled application as follows:

Claim 15, line 3, after "element" and before the  
comma, insert --for influencing the space current flow there-  
through in accordance with waves impressed thereon, --; line  
4, cancel "therefor" and substitute --for said devices--.

Claim 16, lines 3 and 4, cancel "elements for varying  
the impedance of said spaces respectively" and substitute  
--means including impedance varying elements for causing the  
impedance of said spaces to vary differently at different  
instants--.

Cancel claim 22 and substitute the following as claim

22:

22. In a signaling system, a power limiting de-  
vice comprising an electron discharge device having an input  
circuit and an output circuit, a source of variable current  
connected to said input circuit, a path in said output cir-  
cuit through which amplified variations from said source are  
constrained to pass, and a resistance located in said path

FORM NO. 15  
COMMUNICATIONS TO  
PATENT OFFICE  
5-17-1918



(Serial No. 48,873) 2

of such a value that waves of a normal value from said source will produce desired variations of current through said path, but impulses of a greater voltage will produce current having a maximum value not materially greater than the maximum value of current produced by waves of normal voltage applied to said input circuit.

Cancel claim 23 and substitute the following as claim

23:

E4  
23. In a signaling system, a power limiting device comprising an electron discharge device having input and output circuits, a source of space current for said output circuit, a path in said output circuit through which alternating current components are constrained to flow and a resistance in said path, said source and said resistance being of such values that incoming signal waves will produce desired changes of current, but incoming waves of greater strength will produce only negligibly larger changes of current through said path.

add the following as claims 29 and 30:

E5  
29. The method of overcoming the effects of static disturbances in a wireless signaling system which consists in producing at a receiving station by means of the signaling current an alternating current having a frequency much lower than the transmitted radio frequency current, and passing this current through a circuit containing a device for limiting the energy passing therethrough to a predetermined value.

30. The method of overcoming the effects of static disturbances in a wireless telephone receiving system which consists in first detecting the received signaling waves, thereby producing a varying current having a fre-

Serial No. 48,8751 3

frequency much lower than the received waves; passing this current through a circuit containing a device for limiting the energy passing therethrough to a predetermined value and reproducing the telephone signal by the current passed through said circuit.

Cancel claim 24 and change the numeral of claim 23 to 25.

REMARKS

Claims 15 and 16 have been amended to indicate a cooperative relation between the grids and the remaining elements set forth in the claims. This relation consists in the fact that means are provided whereby although the grids vary the impedance of the two spaces, nevertheless, the sum of currents therethrough is maintained at a constant value. Furthermore, claim 16 is limited to the case where the grids or control elements cause different variations in the impedance of the two spaces at different instants.

Claims 22 and 23 have been amended to distinguish from Arnold by pointing out that the current limiting resistance is in the part of the plate current circuit through which the alternating component of the plate current is constrained to flow. In each of the modifications disclosed by Arnold, the resistance is in the direct current path of the output circuit, but has a shunt path therearound traversable by alternating current through which the alternating component flows. In the case of impulsive disturbances large increases of current can occur in the shunt path for short periods of time. These would tend to cause disturbances which the present arrangement is designed to prohibit. Furthermore, it should be pointed out



1040

(Serial No. 48,873) 4

out that in a radio system sudden disturbances of short duration are likely to be caused by static.

Claims 29 and 30 which have been added are believed to define novel subject-matter patentable to applicant. These claims cover the method of static reduction which consists in first detecting or otherwise reducing the frequency of the incoming signaling wave and thereafter passing the resulting alternating current through a power limiting device. Claim 29 corresponds to the claim 25 which is under final rejection in the application of Alexandersen, Serial No. 92,156, filed April 19, 1916. Applicant has recently had access to this application as a result of an interference. This claim is rejected in Alexandersen's application on British patent 5,373 of 1915 in view of Hammond 1,274,364. It is noted that Arnold's filing date is prior to the publication of the British patent which is no reference against Arnold's claims 29 and 30 for this reason.

This amendment is made with the understanding that it will be entered and considered by the Examiner in accordance with the understanding had at a recent oral interview.

It is believed that the application is in condition for allowance, which action is respectfully requested.

Respectfully,

HAROLD D. ARNOLD

By W. C. A. Hargrave  
Attorney.

443 East Street,  
New York, Oct. 20, 1920.

JMS:3

64/49

1941

Letter No. 15

ADDRESS ONLY  
THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

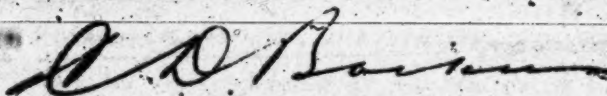
March 14, 1921

The Hon. Commissioner of Patents,

Sir:

It is requested that the application of H. D. ARNOLD, Serial No. 46,875, filed Sept. 3, 1915, for Power Limiting Amplifying Devices, be withdrawn from issue for the purpose of including it in interference, declaration of which was approved by the Law Examiner on March 7, 1921.

Respectfully,

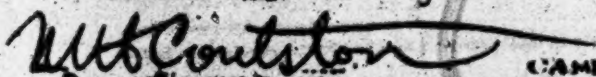


Ext., Div. 16.

H. S. M.

Approved:

MAR 17 1921



CAME:

WITHDRAWN FROM FILE OF  
ISSUE AND GAZETTE DIVISION  
24 MAR 15 1921



# INTERFERENCE.

Interference No. **45944**

Paper No. 16

Name **Harold D. Arnold.**Serial No. **48873.**Title, **Power Limiting Amplifying Devices.**

Filed, Sept. 3, 1916

Interference with **R. F. W. Alexanderson**

## DECISIONS OF

Primary Examiner, \_\_\_\_\_

Dated, \_\_\_\_\_

Ex'r of Interferences, \_\_\_\_\_

*Notable*

Dated, \_\_\_\_\_

*Dec. 2/21*

Board, \_\_\_\_\_

Dated, \_\_\_\_\_

Commissioner, \_\_\_\_\_

Dated, \_\_\_\_\_

## REMARKS:

This should be placed in each application or patent involved in interference in addition to the interference notice by Primary Examiner.

Apr. 27, 1921

DEPARTMENT OF THE INTERIOR,  
UNITED STATES PATENT OFFICE, "A"  
WASHINGTON, D. C.

Mr. John G. Roberts,

465 West St.,

New York, N. Y.

U. S. PATENT OFFICE  
MAY 5 1921  
MAILED

Please find below a copy of a communication from the Examiner concerning the  
Harold D. Arnold, Ser. 448,873, filed Sept. 3, 1915.

Power Limiting Amplifying Devices.

Room No. ....

Very respectfully,

THOS. E. ROBERTSON

ADDRESS ONLY  
THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.

Commissioner of Patents.

45944

The case, above referred to, is adjudged to interfere with others, hereafter specified,  
and the question of priority will be determined in conformity with the Rules.

The statement demanded, by Rule 110 must be sealed up and filed on or before

MAY 31 1921

with the subject of the invention, and name of  
party filing it, indorsed on the envelope. The subject-matter involved in the interference is

1. The method of overcoming the effects of static disturbances in a wireless signaling system, which consists in producing at a receiving station by means of the signaling current having a frequency much lower than the transmitted radio frequency current, and passing this current through a circuit containing a device for limiting the energy passing therethrough to a predetermined value.

The interference involves your application above identified; and

An application for Wireless Signaling Systems, filed by Ernst F. W. Alexanderson, of General Electric Company, Schenectady, N. Y., whose attorney is Albert G. Davis, of Schenectady, N. Y., and whose assignee is General Electric Company, a corporation of New York.

The count of the interference is claim 25 of ALEXANDERSON and claim 29 of ARNOLD.

HLM

*W. O. Baisan*  
3. Du 16



1044

✓ Case 18  
 PAPER BY 18  
 AMENDMENT.

## UNITED STATES PATENT OFFICE.

Division 18 Room 112

(R. 78-Not enter)



In re application of  
 HAROLD D. ARNOLD

Subject.

RADIO COMMUNICATION **13**

Serial No. 48,873

Filed September 3, 1915  
 Allowed February 9, 1922.  
 Final fee not paid.

THE COMMISSIONER OF PATENTS,  
 Washington, D. C.



Sir:

Applicant respectfully petitions entry of the following amendment under the provisions of Rule 78 without withdrawing the application from issue.

Page 2, line 6, change "Its" to --An--.

Page 3, lines 5 to 7, cancel "being essential to the operation of the device for the purpose specified by preventing unbalanced currents in the two halves of the device" and substitute therefor --performing an important function in connection with the power or current limiting action of the device as hereinafter described--.

Page 4, line 18, after "leak" insert --which is--;  
 line 25, cancel "rectifier" and substitute --detector--.

Please add the following claims:

1. The method of reducing detrimental effects of disturbing waves superimposed on waves to be received at a receiving station which comprises utilizing the energy of the received waves to produce a current which varies in amplitude at a frequency widely different from that of the received waves, and passing this current through a circuit containing a

(Serial No. 48,873)

- 2 -

device for limiting the energy passing therethrough to a predetermined value.

32. A system for reducing the detrimental effects of disturbing waves superimposed on waves to be received which comprises devices for producing at a receiving station by means of the received waves an alternating current of a widely different frequency from that of the received waves, a circuit through which the alternating current is to be passed, and means for limiting to a predetermined value the energy passing through said circuit.

33. In an electric system, an incoming circuit and a plural stage amplifier for amplifying signals from said circuit, the last stage of said amplifier comprising two vacuum tube repeaters connected in push-pull relation, and another of said stages comprising only a single vacuum tube repeater.

34. In an electric system, a plural stage amplifier for amplifying signals adapted to be connected to an incoming circuit from which the signals are received, the last stage of said amplifier comprising two vacuum tube repeaters connected in push-pull relation, another of said stages comprising only a single vacuum tube repeater, a receiving device, and a transformer for coupling said device to the output circuit of said last stage.



35. A high frequency receiving system comprising means for detecting high frequency received oscillations, a receiving device for translating electric waves into energy of a different form, and a plural stage repeater between said detecting means and said device for impressing on said device the detected currents in an amplified form, said plural stage repeater comprising a push-pull vacuum tube repeater in only the last stage thereof.

36. An amplifier circuit for electric wave energy comprising an amplifying stage consisting of a single vacuum tube repeater working into a push-pull vacuum tube repeater, the push-pull repeater consisting of tubes having their grid circuits oppositely coupled to the output circuit of the single vacuum tube repeater.

37. An amplifier circuit for electric wave energy of speech frequencies comprising an amplifying stage consisting of a single vacuum tube repeater working into a push-pull vacuum tube repeater, the push-pull repeater consisting of two tubes having their grid circuits oppositely coupled to the output circuit of the single vacuum tube repeater. --

#### R E M A R K S

Proposed claims 32 and 33 are along the line of claims 29 and 30, the former of which constituted the count of interference No. 48,944, in which applicant was awarded priority. The proposed claims are broader than claim 29 in that they are not limited to reducing the frequency of received waves and then

limiting their amplitude but are broad enough to cover increasing by a substantial amount the frequency of the received waves and then limiting the current representing the waves of increased frequency. Apparently, applicant is the first to change the frequency of received waves before limiting the power transferred to a signaling instrument and is entitled to broad claims on this subject matter. The prior art has been carefully considered in connection with the present application and it is believed that the Examiner is so familiar with the art that, notwithstanding the fact that these claims are somewhat broader, they will be found allowable without a new search.

The proposed claims 35 to 37, inclusive, present a novel feature of the invention considered by applicant to have been heretofore insufficiently claimed. These claims are intended to more definitely cover that feature of applicant's invention which may be described in general terms as an amplifier circuit consisting of one or more stages of simple thermionic amplifiers, that is single tubes or a plurality of tubes in parallel in each stage, feeding into one or more succeeding stages consisting of tubes arranged in push-pull relation. It is very advantageous in many instances to use such an arrangement. Relatively small currents transversing the first stages are transmitted in amplified form to the last stage or stages with but small distortion. Simple repeaters in the final stages would largely distort the amplified waves but by making use of tubes in push-pull relation an amplified output of much greater amplitude can be secured with but small distortion. This results from the fact that the use of tubes



(Serial No. 48,875)

- 5 -

in push-pull relation permits of working over a much greater portion of the tube characteristic and, consequently, over a considerable part of the more curved portions with less resultant distortion. For example, if speech currents are to be amplified by the use of not more than three similar tubes, such greater gains can be secured by the use of one tube working into a push-pull arrangement of two tubes than by any other possible circuit employing the same tubes. This permits of much more efficient utilization of the tubes. In other cases not limited to the use of any particular number or design of tubes, the same general principles hold true in that greater amplified currents can be produced in general by using a push-pull repeater in the last stage or stages only of a plural stage amplifier circuit.

Applicant is believed to be the first to employ such an arrangement and, inasmuch as all pertinent references are considered to be of record in this amplification, none of them anticipating the proposed claims, it is considered that the Examiner will be able to recommend the entry and allowance of these claims without a new search.

Favorable action upon the present petition is requested.

Respectfully,

HAROLD D. ARNOLD,

463 West Street,

New York,

June 27, 1922.

By

Harold D. Arnold  
Attorney.

JWS-X

## UNITED STATES PATENT OFFICE

OFFICE

In re application of

HAROLD D. ARNOLD

Serial No. 48,873

Subject: Radio Communication.

Filed September 3, 1915

Allowed February 9, 1922.

## AFFIDAVIT UNDER RULE 48.

JUN 23 1922

State of New York }

County of New York }

ss.

HAROLD D. ARNOLD, being duly sworn, deposes and says:

That he is the person who executed the papers in the above entitled application;

That the subject matter of the present amendment and the amendments filed September 1, 1916, May 9, 1917, June 13, 1918, June 5, 1919 and November 3, 1920, was a part of his invention, was invented before he filed his original application above identified, for such invention, was not known or used before his invention, was not patented or described in a printed publication in any country more than two years before his application, was not patented in any foreign country on an application filed by himself or his legal representatives or assigns more than twelve months prior to his application, was not in public use or on sale in this country for more than two years before the date of his application, and has not been abandoned.

*Harold D. Arnold*

Sworn to and subscribed before me

this 27th day of June, 1922.

*Charles E. Smith*  
NOTARY PUBLIC, Queens County Notary Public.

JVS:1

Queens County Clerk's No. 1174  
Certificate filed in New York County  
Clerk's Office: May 1, 1921  
Commission Expires March 20th, 1924



1050

Div. 16 Room 112 CHD/HBM

Paper No. 19

S-861-b

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

June 30, 1922.

Mr. John G. Roberts,

463 West Street,

New York, New York.

In the application of Harold de Forest Arnold, 48,873, filed  
Sept. 3, 1915, for Power Limiting Amplifying Devices, allowed  
Feb. 9, 1922.

The entry of the amendment proposed under Rule 7½ has been dis-  
approved. A copy of the examiner's adverse report appears below.

*Sam E. Roberts*

Commissioner of Patents.

Applicant petitions that a proposed amendment be entered  
under Rule 76 in this application in which the final fee has not  
been paid.

It is recommended that the proposed amendment be not en-  
tered for the reasons hereinafter set forth.

The proposed changes to the specification appear to be  
permissible.

Proposed claims numbered 31 and 32 are considered allowable.

Proposed claims 33, 34 and 36 are considered unpatentable  
for the reason that no invention is required to use for the last  
stage of amplification in a plural stage amplifying system such as  
shown by either of the patents to

Alexanderson, 1,175,079, Feb. 22, 1916, 250-20,  
de Forest, British, 2,059 of 1914, 1 sheet, 250-27,

an amplifier of the push-pull type as shown by COLPITTS, 1,128,292,  
of record, or Fig. 3 of ALEXANDERSON, cited.

Claim 37 is considered unpatentable for the same reasons,

48,873.

2.

for although the claim specifies speech frequencies, de Forest and Colpitts show amplifiers for such frequencies, and this claim does not, by the elements enumerated, set forth anything different from claim 56.

Claim 36 is considered unpatentable for the reason that no invention is required to substitute for the amplifier a' of Fig. 3 of patent to Schloemilch et al., of record, another type of amplifier not involving invention, such as specified in claim 33. There appears to be no novel cooperative relation between the specific form of amplifier and the remaining features set forth.

For these reasons the Examiner's recommendation is adverse.

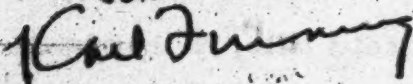
RJM.



Examiner, Division 16.

APPROVED

JUN 30 1922





1052

Case 16

PAPER NO 21  
AMENDMENT

UNITED STATES PATENT OFFICE

Division 16 Room 118

ISSUE DIVISION

JUL 31 1922

U S PATENT OFFICE

In re application of

HAROLD B. ARNOLD

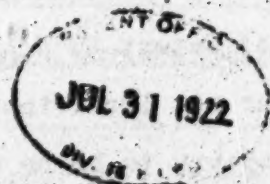
Subject.

Radio Communication.

Serial No. 48,875

Filed September 3, 1915  
Allowed February 9, 1922

THE COMMISSIONER OF PATENTS,  
Washington, D. C.



Sir:

Applicant respectfully petitions entry of the following amendment under the provisions of Rule 78 without withdrawing the application from issue.

Please add the following claim:

--58. In an amplifying apparatus for wireless signals and the like, a plurality of thermionic relays comprising each an evacuated bulb, a plate, a filament and a grid in said bulb, transformers having one of their windings in circuit with the filament and grid of each of said lamps respectively, the other winding of one of said transformers being adapted to be connected to a source of potential, a common source of current in circuit with the plate and filament of each of said relays, and a connection between said source of current and the transformer winding adapted to be connected to a source of potential.--

(Serial No. 48,873)

-2-

**R E M A R K S**

The claim presented herewith is claim 11 of patent No. 1,405,525 to Marius Latour granted February 7, 1922.

An oath under Rule 48 is filed herewith in reference to the above claim.

Respectfully,

HAROLD D. ARNOLD,

By

E. L. Knigge  
Attorney.

463 West Street,

New York, July 25th, 1922.

43:02



# 21

Case 16

UNITED STATES PATENT OFFICE

Division 16 Room 118

In the matter of the application of

HAROLD D. ARNOLD

Serial No. 42,875

Filed September 3, 1918

Radio Communication.

APPEARANCE

JUL 31 1922

State of New York

County of New York

ss.

I, JOSEPH P. MAXFIELD, being duly sworn, depose and say as follows:

I have been in the employ of the Western Electric Company, Incorporated, continuously from July 1914 down to the present. Both before coming into the employ of said company and continuously during such period of employment I have been engaged in studies and researches relating to acoustics. From the beginning of the year 1919 down to the present I have been working on the development of high-quality loud speaker apparatus and on phonographic recording.

I personally have participated in and supervised extensive tests of volume and quality of transmission. Incidental to these tests and to the development of loud speaker apparatus I have been engaged in studies of different types of vacuum tube amplifier circuits.

I am familiar with telephone repeaters and with the requirements put upon them as regards amplification, power output and quality of transmission. The vacuum tube amplifier circuits that have been developed for use as telephone repeaters are wholly inadequate for use as amplifiers for high-power, loud speaker apparatus and in the development of loud speakers

(Serial No. 48,873)

-2-

to their present state of proficiency it was found necessary to adopt amplifiers to meet requirements as to volume and quality of transmission far beyond those placed upon commercial telephone transmission circuits. As examples of the higher standard to be met in loud speaker apparatus a frequency range of from about 60 cycles to about 5,000 cycles is employed, and in many instances a power output of the order of five watts or more is required from the amplifiers in typical loud speaker apparatus; whereas in commercial telephone transmission a frequency range of only about 200 to 2,500 cycles and a power output from the repeater of only the order of 1/20 watt has frequently been provided for. Whereas in telephone repeaters a single stage of amplification is often all that is necessary and two stages of amplification employing a single tube in each stage is ample for practically any situation, in loud speaker apparatus in order to provide the requisite power output a multi-stage amplifier is practically always necessary. The tests above-referred to were for the purpose of comparing different types of amplifier circuits including a type of tube arrangement such as is shown in United States application Serial No. 48,873 of Harold D. Arnold, filed September 3, 1915 to determine the type of circuit capable of giving the greatest amplification with the highest quality of transmission and maximum power output, coupled with an economy of apparatus.

In any multi-stage circuit which, as a whole, is to meet these requirements each stage must have an arrangement and operating characteristics suited to the particular duties which it has to perform by itself and in cooperation with the rest of the circuit. Maximum power output a re-

64/64



quirement particularly of the last stage, with highest quality for any type of tube is obtained by arranging two tubes in balanced, that is, push-pull, relation. Two tubes in a balanced push-pull circuit give high quality even when made to operate over the portion of their static characteristics having a square-law curvature and probably into the initial portion of the range, at least, which begins to obey the cubic law, and in the other direction along the characteristic, up to the point where the grid begins to go positive. For the same quality of output it has been determined that with the type of tube and push-pull circuit used in the No. 2 Public Address systems of the Western Electric Company, Incorporated, the push-pull stage has a power output of the order of 10 times that of one of the tubes alone and of the order of five times the power output of the same two tubes connected in a simple parallel relation. This is on the basis of the same power supply to the tubes in all three instances. It follows that for the same quality of output that is obtained with two tubes of the order of five watts rating, for example, used in push-pull relation, a single tube to give the same power output would need to be of a rating of at least several times 10 watts.

In the stage immediately preceding and working into the push-pull stage it is found that a single tube of the same type and rating as either of the tubes in the push-pull stage <sup>last stage</sup> ~~stage~~ *19A* *KE* ~~would~~ <sup>is</sup> necessary to work the push-pull stage at its high output load and without the single tube introducing distortion beyond the high quality standard set for the entire circuit. To use a push-pull circuit for this stage identical with the succeeding stage would be poor economy since the extra tube not only would contribute no advantage but would

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(Serial No. 48,875)

-4-

actually be a detriment on account of the double chance of burning out a tube and causing the circuit to fail at a critical moment. Added to the cost of the extra tube would be the balanced transformers and greater filament heating and plate current energy necessary for the push-pull circuit.

In general it may be stated that if three tubes of the same type and rating are to be used, the one type of connection which gives the greatest amplification with the greatest output energy and minimum distortion is the connection in which one of the tubes works into the other two in push-pull relation. *1. J. J. Lee*

In all of the high-power high-quality public address systems of my acquaintance which have been developed by the Western Electric Company, Incorporated, many of which have been demonstrated on notable occasions and with high success, the amplifier circuits employed a single amplifier tube working into a push-pull circuit.

While the circuit consisting of a single tube feeding into two tubes arranged in push-pull relation would in my opinion have the same inherent advantages in a variety of uses as those which have been pointed out in connection with loud speakers, I have confined my discussion of it to use in loud speaker apparatus both because I am more especially familiar with its advantages and importance in such apparatus, and because the same or similar considerations as have been pointed out herein would apply in other relations, and the statements made, although with reference to



1058

(Serial No. 48,873)

-5-

a specific type of apparatus may serve as examples.

Joseph P. Maffield

Sworn to and subscribed before

me this 18<sup>th</sup> day of July 1959.

John Canad  
Notary Public.

NOTARY PUBLIC, Queens County  
Queens County Clerk's No. 1194  
Certificate filed in New York County  
Clerk's No. 100; Register's No. 4300  
Commission Expires March 30th, 1964

HAB:QZ

1059

PAPER NO. 2 2

AMENDMENT VI H

## UNITED STATES PATENT OFFICE.

Division 16 Room 118

(R. 78-27  
Entered)

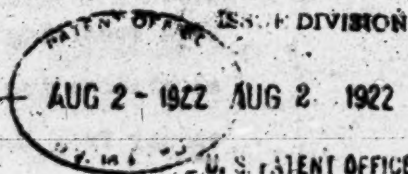
P

AUG  
1922  
U.S. PATENT OFFICEIn re application of  
HAROLD D. ARNOLD

Subject.

RADIO COMMUNICATION.

Serial No. 48,873

Filed September 3, 1915  
Allowed February 9, 1922.THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

Applicant respectfully petitions entry of the following amendment under the provisions of Rule 78 without withdrawing the application from issue.

Page 2, line 6, change "its" to --an--.

Page 3, lines 5 to 7, cancel "being essential to the operation of the device for the purpose specified by preventing unbalanced currents in the two halves of the device" and substitute therefor --performing an important function in connection with the power or current limiting action of the device as hereinafter described--.

Page 4, line 18, after "leak" insert --which is--;  
line 25, cancel "rectifier" and substitute --detector--.

Please add the following claims:

--31. The method of reducing detrimental effects of disturbing waves superimposed on waves to be received at a receiving station which comprises utilizing the energy of the received waves to produce a current which varies in amplitude at a frequency widely different from that of the received waves, and passing this current through a circuit containing a



device for limiting the energy passing therethrough to a predetermined value.

32. A system for reducing the detrimental effects of disturbing waves superimposed on waves to be received which comprises devices for producing at a receiving station by means of the received waves an alternating current of a widely different frequency from that of the received waves, a circuit through which the alternating current is to be passed, and means for limiting to a predetermined value the energy passing through said circuit.

33. In an electric system, an incoming circuit and a plural stage amplifier for amplifying signals from said circuit comprising in one stage of said amplifier two vacuum tube repeaters connected in push-pull relation, and at least one stage consisting of a single vacuum tube amplifier feeding into said push-pull stage,

34. In a plural-stage amplifier circuit in which the amplitude of the repeated current increases in succeeding stages, at least one preliminary stage consisting of a single tube amplifier for amplifying the repeated wave up to a given current amplitude and a succeeding stage consisting of a pair of vacuum tube amplifiers connected in push-pull relation for amplifying the repeated wave up to a much larger current amplitude.

35. In a plural stage amplifier circuit for amplifying signal currents, employing vacuum tube amplifiers in which, for relatively strong output currents at least, as the amplitude of the repeated wave becomes larger the distortion of the wave increases, said amplifier circuit comprising at least one stage consisting of a single vacuum tube repeater operating over a relatively small current amplitude range and giving amplification with the required degree of faithfulness of repetition of the signal and a stage into which said single tube stage, feeds, for amplifying the repeated wave up to a current amplitude at which undesired distortion would take place in a single one of said tubes used alone, said later stage comprising a pair of vacuum tube repeaters connected in push-pull relation, whereby at said large current amplitude a faithfulness of repetition is obtained consistent with that of the preceding stage.

36. In combination, three electron discharge tubes, means for supplying discharge current to said tubes, two of said tubes being connected in push-pull relation, the other one of said tubes being arranged to impress amplified signal waves on said push-pull connected tubes of such amplitude that at the peak amplitude of said waves, for a given half-cycle the resultant momentary decrease in the normal discharge current



through one of said push-pull connected tubes reduces the discharge current through said tube near to zero.

37. In combination a pair of space discharge devices, each of said devices having a cathode, an anode and a grid or control element, anode circuits and grid circuits for said devices, a common source of discharge current connected to said anodes, a common source of alternating current potential connected to said grids, said devices being connected to operate in push-pull relation, the normal discharge current through said tubes being so related to the amplitude of the alternating potential impressed on said grids that at the peak amplitude of said alternating potential the space current through one and the other of said devices alternately is reduced substantially to zero.

39. In an electric system, an incoming circuit and a plural stage amplifier for amplifying signals from said circuit, said amplifier comprising at least one stage consisting of a single electron discharge tube and a stage consisting of a pair of electron discharge tubes connected in push-pull relation, having their input sides connected to the output side of said first mentioned stage, means for supplying discharge current to said tubes, the amplitude

(Serial No. 48,873)

-5-

of the signal variations in the discharge current of said push-pull tubes being of the order of magnitude of the normal discharge current through said tubes.

40. A high-frequency receiving system comprising means for detecting high frequency received oscillations, a receiving device for translating electric waves into energy of a different form, and a plural stage repeater between said detecting means and said device for impressing on said device the detected currents in an amplified form, said plural stage repeater comprising at least one stage consisting of a single vacuum tube amplifier, the final stage consisting of a push-pull vacuum tube repeater.--

#### R E M A R K S

Claims 31 and 32 presented herewith are similarly numbered claims of the amendment of June 27, 1922, petitioned entry under Rule 78, which claims were indicated as allowable in the Office letter of June 30, 1922.

Claim 33 is presented in accordance with the suggestion of the Examiner in a recent interview, and claims 34 to 37 and 39 are drawn along lines discussed at the interview. Claim 40 is modeled after claim 35 of the amendment of June 27, 1922, but is more specific.



The Examiner is respectfully referred to the affidavit of Joseph F. Maxfield filed July 29, 1922, for the statements contained therein as to the very significant, valuable and not-to-be-expected results obtained from the combination of a single tube amplifier feeding into a push-pull circuit. Reference is made also to the remarks at the end of the amendment of June 27, 1922.

Consideration of these statements, as was pointed out in the recent oral interview with the Examiner will make it evident that the one way to associate three amplifiers to secure the greatest amplification with the greatest power output and minimum of distortion is by arranging one of the tubes to feed into the other two in push-pull relation. The remarkably high efficiency of such a circuit comes from the fact that the push-pull circuit can be loaded to work over the curved part of the tube characteristic to a considerable extent and still give high quality, and from the further fact that a single tube is amply sufficient to supply the power necessary to load the push-pull tubes to this extent. For quantitative comparisons and a more complete explanation, the affidavit and the remarks above identified are referred to.

It is submitted that claim 22, to a specific combination from which striking new results are obtained as explained in the interview with the Examiner and as attested by Maxfield's affidavit, is not anticipated by ideas found in Alexanderson 1,173,079 or British 2,059-1914 or Colpitts 1,123,392, all of record. This combination is specific to the arrangement in which the single

(Serial No. 48,673)

-7-

tube precedes and feeds into the push-pull stage. It is only from this particular arrangement that the particularly advantageous results flow, - namely, greatest amplification with greatest power output at highest quality.

It is respectfully pointed out that there is no suggestion in Colpitts 1,126,292 of using a push-pull circuit in a multi-stage amplifier. Page 1, lines 16 and 17 and 20 to 23 of the Colpitts specification, together with the entire description, would, it is submitted, rather suggest that the results aimed at in the patent are attained in a repeater consisting merely of a single push-pull circuit. If for any reason one should desire to use two stages, and secure the improved quality which this patent sets forth as attained by the push-pull circuits, it would be obvious to use the push-pull circuit in both stages, but it would be most illogical and unexpected that one should, in the light of this patent, use a single tube amplifier in one stage and a push-pull circuit in another. And if one were even to use a push-pull in one stage and a single tube in another it would seem quite fortuitous for one to place the single tube ahead of the push-pull stage. If it is to be presumed that the amplifiers are to be placed in this specific arrangement some reason must be attributed for so doing, and it is respectfully submitted that this reason must come from somewhere besides anything contained in the patents of record. In other words this combination results from



an idea not found in the patents of record and which, it is believed, could not be supplied by these patents. It remained for applicant to hit upon and disclose this simple but exceedingly valuable combination. Since this claim defines the exact arrangement of tubes from which the surprising results referred to are obtained, in that it is specific to the push-pull succeeding the single tube amplifier, it is respectfully urged that the claim accurately and sufficiently defines a novel combination which of itself gives results not to be expected, and that the claim is patentable.

Claim 34 is drawn from a somewhat different point of view and is believed clearly patentable for the same reasons as pointed out in connection with claim 33.

In connection with claim 35 it is respectfully pointed out that on the last page of applicant's specification the signal variations in the current through one of the push-pull tubes are described as approximately equal to those simultaneously taking place in the current through the other, and that these variations can be nearly as great as the normal space current - assumptions which are amply justified in view of measurements taken with a circuit of this type. These conditions enable the high-power high-quality output called for in claim 35 to be attained in the push-pull stage. Current variations of this amplitude in a single tube of the same rating, if they were possible, would be badly distorted.

Claims 36, 37, and 39 include quantitative relations clearly not found in the art but relations which characterize the invention and lead to the valuable results.

(Serial No. 48,873)

-9-

referred to above.

Claim 40 sets out a combination in which the final stage of a plural-stage amplifier in a radio receiving system comprises a push-pull circuit. Such a circuit enables high-amplification of the relatively weak received signals and large power output with minimum distortion - all of which are essential factors particularly in a receiving system in which the receiving instrument requires considerable power as is frequently the case.

The claims as presented are believed clearly allowable.

Entry of this amendment is respectfully petitioned.

Respectfully,

HAROLD D. ARNOLD,

By W. L. Quinn  
Attorney.

463 West Street,

New York, Aug. 1., 1922.

HAB:QE



1068

Div. 16 Room 112

HSM:123

20-51-b

Form No. 25

Examination of the application for a patent on the basis of the claims as presented in the application.

## DEPARTMENT OF THE INTERIOR

## UNITED STATES PATENT OFFICE

WASHINGTON

August 7, 1922

Mr. John G. Roberts,

463 West St.,

New York, N. Y.

In the application of Ser. #46,873, filed Sept. 3, 1915, by

Harold D. Arnold,

Allowed Feb. 9, 1922.

## Power Limiting Amplifying Devices.

The entry of the amendment proposed under Rule 78 has been disapproved. A copy of the examiner's adverse report appears below.

*Thomas E. Robinson*

Commissioner of Patents.

Two amendments containing proposed claims 31 to 40 were filed July 29 and Aug. 2, 1922, respectively, in this application in which the final fee has not been paid. It is recommended that these amendments be not entered for the following reasons:

Claim 33 is considered unpatentable for the reasons set forth in the Examiner's Statement dated June 30, 1922. The unexpected result, namely, efficiency in amplification, to be attained from using tubes arranged as specified in this claim and relied on to establish patentability is based, as it appears from the affidavit filed, on using tubes primarily as amplifiers, and this efficiency in amplification is not necessarily inherent in a power limiting device as disclosed by applicant where the amplification is largely reduced by the inclusion of choke coil <sup>and</sup> high resistance and where, as a matter of fact, no amplification at all in the power limiting device is essential to the operation of the system as disclosed by applicant in the <sup>application</sup> originally filed.

Ser. #48,673 - 2.

The subject matter of claim 34 is not disclosed in the application as originally filed, there being no disclosure of the features specified in lines 9 and 10, "up to a much larger current amplitude"; as pointed out above, it was unnecessary for applicant's objects as stated in the original specification to have any amplification in the power limiting device, and if there should be any amplification, the original specification is silent as to whether the current amplitude is a little larger or much larger as now claimed.

Claim 35 is drawn to subject matter not disclosed in the application as originally filed, there being no mention in the original specification of the features specified in lines 8 and 9 of the claim, nor of the features specified in lines 14 to 15.

Applicant has no right to make proposed claim 38 with the meaning it has in the patent to LATOUR, 1,405,523, from which it was copied. The connection specified in the last three lines of the claim has a definite function in Latour's device, while in applicant's device, there is only incidentally a connection because the cathode is grounded and the antenna also grounded. The incidental connection appears to have no function in applicant's device. Applicant's invention, as stated in his objects, would be the same if an ungrounded loop antenna were used, but obviously, the claim would not then read on such a construction. Furthermore, the definite function which the connection of Latour has is specified in Latour's claim, namely, for connection to a source of potential. The earth could not be considered a source of potential.

Claim 40 covers an old combination as shown by either GABOT, 916,840, March 30, 1909, 250-20x; or SCHLOM ILSON ET AL, 1,163,180, Dec. 7, 1916, 250-20.



Ser. #48,673 - 3.

If the plural-stage repeater is believed to be novel, it should be claimed by itself. However, it is believed no invention is required to substitute for any of the stages as shown in the references other stages of well known form, as a vacuum tube or a push-pull vacuum tube repeater.

For these reasons, the examiner's recommendation is adverse.

Claims 31, 32, 36, 37 and 39 appear to be allowable.

HSM.

C. D. Baird

Exr., Div. 16.

APPROVED

AUG 1922  
Karl J. J. J.  
COMMISSIONER, PATENT

Case 16 <sup>24</sup> 1071

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REC'D  
SEP 14 1922  
U.S. PAT. OFFICE  
16  
20

UNITED STATES PATENT OFFICE  
Room 112

9

In re application of

HAROLD D. ARNOLD

Subject:

Power Limiting Amplifying  
Devices.

Serial No. 48,873

Filed September 3, 1915  
Allowed February 9, 1922

PATENT OFFICE  
SEP 18 1922

P E T I T I O N

TO THE COMMISSIONER OF PATENTS:

Your petitioner, HAROLD D. ARNOLD, a citizen of the United States and a resident of Maplewood, in the County of Essex and State of New Jersey, whose post-office address is 40 Ridgewood Terrace, Maplewood, New Jersey, represents that on September 3, 1915, he filed an application for letters patent for an improvement in POWER LIMITING AMPLIFYING DEVICES, serial number 48,873, which application was allowed February 9, 1922, but that he failed to make payment of the final fee within the time allowed by law. He now makes renewed application for letters patent for said invention, and prays that the original specification, oath and drawings may be used as a part of this application.

HAROLD D. ARNOLD

By W. Whigg

463 West Street,  
New York, Sept 13; 1922.



1072

Oct 16

MAIL ROOM  
SEP 15 1922  
UNITED STATES PATENT OFFICE

PAPER NO. 25  
AMENDMENT. *I*

Division 16 Room 118

A 281

In re application of  
HAROLD D. ARNOLD

Subject:

Power Limiting Amplifying  
Devices.

*I*  
Serial No. 48,673  
Filed September 3, 1915  
Allowed February 9, 1922

THE COMMISSIONER OF PATENTS,  
Washington, D. C.



Sir:

Please amend the above identified application as follows:

✓ Page 2, line 6, change "Its" to --An--.

✓ Page 3, lines 5 to 7, cancel "being essential to the operation of the device for the purpose specified by preventing unbalanced currents in the two halves of the device" and substitute therefor --performing an important function in connection with the power or current limiting action of the device as hereinafter described--.

✓ Page 4, line 13, after "leak" insert --which is--;  
line 15, cancel "rectifier" and substitute --detector--.

✓ Please add the following claims:

*I2*  
31. The method of reducing detrimental effects of disturbing waves superimposed on waves to be received at a receiving station which comprises utilizing the energy of the received waves to produce a current which varies in amplitude at a frequency widely different from that of the received waves, and passing this current through a circuit containing a device for limiting the energy

passing therethrough to a predetermined value,

32. A system for reducing the detrimental effects of disturbing waves superimposed on waves to be received which comprises devices for producing at a receiving station by means of the received waves an alternating current of a widely different frequency from that of the received waves, a circuit through which the alternating current is to be passed, and means for limiting to a predetermined value the energy passing through said circuit.

33. In an electric system, an incoming circuit and a plural stage amplifier for amplifying signals from said circuit comprising in one stage of said amplifier two vacuum tube repeaters connected in push-pull relation, and at least one stage consisting of a single vacuum tube amplifier feeding into said push-pull stage.

34. In an amplifying system in which the amplitude of the current increases in succeeding stages, a current responsive device actuated by the energy from said system, at least one preliminary amplifying stage consisting of a <sup>single</sup> ~~simple~~ vacuum tube amplifier circuit, and a succeeding stage for delivering the amplified current to said responsive device, said last mentioned stage comprising a pair of vacuum tube amplifiers connected in push-pull relation.



35. In a plural stage amplifier circuit for amplifying signal currents, employing vacuum tube amplifiers in which, for relatively strong output currents at least, as the amplitude of the repeated wave becomes larger the distortion of the wave increases, said amplifier circuit comprising at least one stage consisting of a single vacuum tube repeater operating over a relatively small current amplitude range and giving amplification with the required degree of faithfulness of repetition of the signal and a stage into which said single tube stage feeds, for amplifying the repeated wave up to a current amplitude at which undesired distortion would take place in a single one of said tubes used alone, said later stage comprising a pair of vacuum tube repeaters connected in push-pull relation, whereby at said large current amplitude a faithfulness of repetition is obtained consistent with that of the preceding stage.

36. In combination, three electron discharge tubes, means for supplying discharge current to said tubes, two of said tubes being connected in push-pull relation, the other one of said tubes being arranged to impress amplified signal waves on said push-pull connected tubes of such amplitude that at the peak amplitude of said waves, for a given half-cycle the resultant momentary decrease in the normal discharge current through one of said push-pull connected tubes reduces the discharge current through said tube near to zero.

(Serial No. 48,873)

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37. In combination a pair of space discharge devices, each of said devices having a cathode, an anode and a grid or control element, anode circuits and grid circuits for said devices, a common source of discharge current connected to said anodes, a common source of alternating current potential connected to said grids, said devices being connected to operate in push-pull relation, the normal discharge current through said tubes being so related to the amplitude of the alternating potential impressed on said grids that at the peak amplitude of said alternating potential the space current through one and the other of said devices alternately is reduced substantially to zero.

*Per L*

38. In an amplifying apparatus for wireless signals and the like, a plurality of thermionic relays comprising each an evacuated bulb, a plate, a filament and a grid in said bulb, transformers having one of their windings in circuit with the filament and grid of each of said lamps respectively, the other winding of one of said transformers being adapted to be connected to a source of potential, a common source of current in circuit with the plate and filament of each of said relays, and a connection between said source of current and the transformer winding adapted to be connected to a source of potential.

38 39. In an electric system, an incoming circuit and a plural stage amplifier for amplifying signals from said circuit, said amplifier comprising



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at least one stage consisting of a single electron discharge tube and a stage consisting of a pair of electron discharge tubes connected in push-pull relation, having their input sides connected to the output side of said first mentioned stage, means for supplying discharge current to said tubes, the amplitude of the signal variations in the discharge current of said push-pull tubes being of the order of magnitude of the normal discharge current through said tubes.

### R E M A R K S

Claims 31, 32, 36, 37 and 39 of this amendment are the same as the correspondingly numbered claims presented in the amendment filed August 2, 1922 for entry under Rule 78. These claims were indicated as allowable in the Office letter of August 7, 1922.

Claims 33 and 35 are likewise claims 33 and 35 of said amendment and are presented for reconsideration for reasons indicated below.

Claim 34 is modeled after claim 34 of said amendment and reconsideration of this claim in its present form is requested for reasons indicated below.

Claim 38 is the same as the claim which was presented for entry under Rule 78 in an amendment filed July 29, 1922, this claim being copied from the Latour patent 1,405,523 (claim 11).

In applicant's original specification at page 2, lines 27 to 29, the power-limiting device is described as ~~also having an amplifying effect which makes the device~~

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particularly applicable in radio communication.

At various places in the specification, such as at page 4, lines 25, 31, 32, etc. the vacuum tubes 31 and 38 are identified as amplifiers. This circuit has altogether four stages of amplification, not counting the detector as contributing any amplification; that is, one stage of high-frequency amplification, the two stages of audio-frequency amplification represented by the tubes 31 and 38, and the final stage comprising the power limiter. In the final stage the signaling currents have an amplitude just short of the normal space current through the tubes (page 6, lines 15 and 16).

In the operation of the push-pull stage as an amplifier for the normal signaling currents, the resistance 58 and choke coil 57 do not come into play to cut down the transmitted oscillations since the path taken by these oscillations does not include the elements 57 and 58. That is, the current through 57 and 58 remains a constant until the space current in one of the two tubes has reached zero or substantially zero. So long as the current variations in one tube just balance those in the other, the elements 57 and 58 are not called upon to transmit any more current regardless of the amplitude of the signals. These elements help to determine a certain normal space current, but they in no way impede the production of complementary current variations in the two tubes up to an extreme amplitude of the order of magnitude of this normal space current. (See pages 5 and 6 of the specification).

All of the above is but a restatement of what is clearly explained in the original specification.



The Examiner's grounds for not admitting claim 35 are two:- namely, the ground given in the Office letter of June 30, 1922, and the new and additional grounds stated in the Office letter of August 7, 1922. The latter will be taken up first.

These latter grounds are understood to be that the tubes called for in the claim and as disclosed in the specification are not "primarily" amplifiers, whereas the new result which applicant has established is not inherent in a device such as is described where the device is merely a power-limiter, and (impliedly) not an amplifier. The obvious and sufficient answer to this is the claim itself and the specification. The Examiner's attention is called to the fact that the affidavit and the arguments and amendments which have been presented are not relied on for showing that these tubes called for in the claim are amplifiers. The references made at the beginning of these remarks to portions of the specification point out that the original disclosure affords ample basis for this claim. The language of the claim is unmistakably clear in calling for amplifiers and not merely "tubes". It has further been pointed out above that the amplifying and power-limiting functions of the push-pull stage are to an extent independent in that the power-limiting action takes place only after the maximum signaling amplitude has been reached. Up to that point amplification takes place. Whether or not this push-pull stage is primarily an amplifier or is primarily something else, is entirely beside the question. It is an amplifier and is claimed as such. The affidavit was submitted merely to show that the sub-combination being claimed is accompanied by new and unexpected results, in the high efficiencies obtained with it.

It is also beside the question whether or not amplification is inherent in a power-limiting device. It is conceivable that in power limiters in general, of the type shown, there might or might not be amplification depending on the circuit structure. But there is no necessity for conjectures on this point. The specification is in no way inconsistent or obscure in this, for it clearly says that the power-limiter amplifies and is not seen to contain anything to lead anyone to conclude or assume that it might not amplify.

There is therefore a sufficient basis in the original specification for this claim, and unless the obvious meanings of the words used in the claim are to be ignored altogether, there can be no question that what the claim calls for is an amplifying stage in push-pull and a single tube amplifier feeding into the push-pull stage; and not merely a combination of vacuum tubes in which no amplification may be present.

The other ground for not admitting this claim, as stated in the Office letter of June 30, is in effect that no invention would be required to build up the combination claimed, its elements being old. It was pointed out in the remarks accompanying the proposed amendment filed August 2, 1922 that the combination claimed is specific to the push-pull stage following the single stage, and that not only would it be unexpected that one should, in the light of the prior art, combine a push-pull circuit with a single tube amplifier at all, but that there would be no known reason for adopting the specific combination claimed until applicant discovered that the push-pull circuit could be loaded for signal amplification to the point where the space current is reduced near to zero by the signals. With this came the idea of using a



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single tube to load the push-pull stage up to this high efficiency point. It is this combination which has proved to have the high efficiency spoken of in the affidavit and due to this specific arrangement three tubes can accomplish in high current amplification what heretofore required a larger number.

But even though the Examiner's holding that no invention would be required to combine amplifiers in this way were a correct holding, which applicant respectfully maintains is not the case, this ground is not sufficient where a new result is obtained with the new combination.

In ex parte McCollum, (C.D. of 1914, page 70) a claim was held to be patentable where it specified structure that could, impliedly without invention, have been assembled from old structures. But the slide valve from Herreshoff's steam engine if substituted in Turcot's gas engine would in its new relation perform the work which previously required two valves. The accomplishment of this result was taken as evidencing invention and as deserving of patentability since:

"If the structures of the references may be combined or substituted one for the other and the combined function or result is new, the claim should be allowed." (C.D. of 1914, page 73, lines 9 to 11.)

It is not sufficient therefore, merely to say that structures may be combined without invention and to reject a claim on that ground. The new result must not be ignored. In applicant's case the plural stage amplifier defined in claim 33 will give the same output current at given quality that could be obtained only with several more tubes if some other type of connection were used. This new result has been amply proved, and the claim should, it is respectfully submitted, be allowed.

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Claim 34 has been redrawn. It is believed to be clearly supported by the original disclosure in view of the fact that the push-pull stage is disclosed as an amplifier for the signaling currents. All of the remarks in connection with claim 33 are applicable also to this claim and it should be allowed for the same reasons.

Claim 35 is believed clearly readable on the original disclosure. The single tube amplifier of line 8 may be either 31 or 38. The very purpose and object in using three stages of audio-frequency amplification in this circuit is to obtain an increased current output, and if there is any advantage at all in using several stages it must come from the fact that the current increases in succeeding stages. Therefore by necessity the current amplitude range over which either tube 31 or 38 operates must be smaller than that over which the push-pull stage operates. The language of lines 8 and 9 is clearly supported since it defines increasing current in successive stages. Lines 14 and 15 define in different terms the limitation contained in claims 36, 37 and 39, on account of which these claims were apparently allowed. If the amplitude of the plate current variations in a single amplifier tube exceeds the relatively small range throughout which the tube has a substantially straight line characteristic the repeated wave is distorted, and the greater the amplitude beyond this range the greater the distortion. The original description states that the amplitude of the signals in the push-pull stage is nearly equal to the normal space current through the tubes. If the signals through a single tube had this amplitude they would be very badly distorted. Since the push-pull stage amplifies, and since the signal variations are nearly equal in amplitude to the normal space current, it is clear that they have a



greater amplitude than they could have in the case of a single tube without being badly distorted. This language, therefore, merely presents in different terms the idea of the large current variations that can occur in the push-pull stage and on account of which the high efficiency is possible. It should be noted that the amount of distortion is a question of first importance in signal amplifiers. The lack of it is a measure of quality. If amplitude alone were of interest a single tube could be used, since by reducing its space current to zero the same amplitude of variation could be produced, but neither the applicant nor any other person skilled in the signalling art at the time of filing of this application would have attempted to repeat signals such as speech at such a high amplitude through a single tube repeater as to reduce the space current in it near to zero. To do so would distort the signals too badly. Applicant did however, disclose a series amplifying arrangement by which he could increase the current amplitude of the signals in successive stages, and in the last stage of which, due to the push-pull connection, the signals could be nearly equal to the space current in amplitude. As defined in this claim, the current operating range in one of the single tubes is small relatively to that of the push-pull tubes, which are operated at an amplitude so great that undesired distortion would be produced in a single tube with the same amplitude of signal. This claim is, therefore, believed to be amply supported by the original disclosure and to be allowable for the same reasons as are given above in connection with claims 33 and 34.

It is not seen that claim 36 copied from the Latour patent has any different meaning in Latour from what it has in the present application. The Examiner has not indicated any particular meaning or force which the claim has in Latour except as regards the connection to the transformer winding.

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By referring to page 4 of Latour's specification line 118 to the end of the specification, it is seen that the object of the connection from the battery P (Fig. 3) to the masses  $M_1$ ,  $M_2$  and  $M_3$  as well as to the primary of  $T_1$  is to define the potential of these portions of the circuit. By connecting these points all together static charges are prevented from building up between parts of the circuit where they might conceivably cause singing. The claim does not include the cores of the transformers nor bring in any function or result for the potential-defining connection. It appears therefore, that this claim attempts to cover broadly a connection from the primary of one of the transformers to the plate-filament circuit of the tubes to prevent the effect of electrostatic potentials between this primary and the plate-filament circuit. Such an a.c. static potential is undesirable as not only causing howling, but as also lowering the efficiency of the transformer. The effect of the conductive connection between the winding 2 and the point 60 of applicant's circuit via the earth would be to tend to prevent the primary 2 from assuming a high static potential relative to the plate-filament circuit and so cause electrostatic transfer across between the primary and secondary of the input transformer, thus reducing the efficiency of the transformer. The patentee could have readily limited his claim 11, as by including the transformer cores for example. Since he did not so limit the claim, it appears in effect to cover other specific circuits disclosed than the patentee/including that which applicant has invented and disclosed, and applicant should be allowed to contest this claim.

The claim may be read element for element on applicant's



circuit as follows: The thermionic relays are applicant's tubes 7 and 21, each of which has a filament, a grid and a plate. The two transformers are 2, 5 and 13, 14 respectively, each of which has a winding in the grid-filament circuit of one of said tubes. The "other winding" of applicant's transformer 2, 5, namely the winding 2, is connected to the antenna which is certainly as much a source of potential as Latour shows for feeding his transformer 2<sub>1</sub>. The common plate source is the battery 15 and the connection from this battery to the primary 2 (which as stated above is connected to the source of potential \_\_\_\_\_ the antenna) is by way of ground.

Applicant cannot agree that any function is stated in Latour's claim for his connection, nor that in reality it has a different function from applicant's connection of several points of his circuit to ground. In both cases the purpose is to maintain the various parts of the circuit so connected at the same potential. If it is "incidental" that applicant shows a grounded antenna it must not be concluded as also incidental that he has grounded the receiving circuit at various other points including the plate battery, the particular point of the circuit specified in Latour's claim. It is further an auxiliary object of any invention, though it may not be so specifically stated in the specification, to make the entire circuit or other arrangement of the particular and preferred form that is described, an efficient system for accomplishing the main objects of the invention. This should be self-evident.

All of the Examiner's objections against admitting claim 25 for purposes of interference appear to be without ground, and it is respectfully requested that this claim be

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entered and allowed applicant either with or without the formality of an interference.

Reconsideration of all of the above claims, and allowance, are respectfully requested.

Respectfully,

HAROLD D. ARNOLD

BY G. W. Griggs

463 West Street,

New York, Sept. 13., 1922.

HAB:FP



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MAIL ROOM  
SEP 17 1922  
U.S. PATENT OFFICE

Case 16

A 295

## UNITED STATES PATENT OFFICE

Div. 15 Room 112

In re application of

HAROLD D. ARNOLD

Subject:

Serial No. 48,873

Power Limiting Amplifying  
Devices.Filed September 3, 1915  
Allowed February 9, 1922

State of New York )  
County of New York ) ss.

S U P P L E M E N T A L   O A T H

HAROLD D. ARNOLD, whose application for letters patent for an improvement in POWER LIMITING AMPLIFYING DEVICES, Serial No. 48,873, was filed in the United States Patent Office on or about the 3rd day of September, 1915, being duly sworn, deposes and says that the subject matter of the foregoing amendment was part of his invention, was invented before he filed his original application, above identified, for such invention, was not known or used before his invention, was not patented or described in a printed publication in any country more than two years before his application, was not patented in a foreign country on an application filed by his legal representatives or assigns more than twelve months before his application, was not in public use or on sale in this country for more than two years before the date of his application, and has not been abandoned.

*Harold D. Arnold*

Subscribed and sworn to before me  
this 18th day of September, 1922.

*Wm. J. Kelly*  
Notary Public

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Div. 16 Room 112

Paper No. 26

Address only  
The Commissioner of Patents,  
Washington, D. C.  
and not any official by name.

All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

HSM:LBG

## DEPARTMENT OF THE INTERIOR

## UNITED STATES PATENT OFFICE

WASHINGTON

July 12, 1923

Mr. John G. Roberts,

463 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold de F. Arnold, Ser. #588,285, filed Sept. 14, 1922.

Power Limiting Amplifying Devices.

Thomas E. Robertson  
Commissioner of Patents.

This action is responsive to amendment and renewal  
filed Sept. 14, 1922.

This application is informal in this, to wit: The  
residence in the renewal petition differs from that in the  
preamble. The residence should be uniform.

Claim 38 is rejected for the reasons set forth in  
lines 15 to 29, page 2, of Office letter of Aug. 7, 1922.  
The connection specified in line 10 of the claim is in the  
device of Latour, an actual, physical element of combination  
inserted for a definite purpose to give a definite apparatus  
as made clear in Latour's specification. It does not appear  
from applicant's specification that he had in mind the defi-  
nite purpose or the definite apparatus which Latour had in  
mind and defined in this claim. Applicant's grounding of the  
cathode, a feature quite common in the prior art, may inci-  
dentally produce an electrical connection to some other element,  
but such incidental grounding cannot be taken as being the  
equivalent of providing an actual, tangible connection, as is  
done by Latour and called for by the claim, as the earth is  
no part of applicant's invention and should not be considered

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Ser. #588,285 - 2.

as such. The claim calls for a connection between said source of current and the transformer winding; the only connection applicant has provided is connection from the source to the ground and not to the transformer winding. There is no electrical path from the source of current to the transformer without including, in addition, to the connection which applicant has provided, a portion of the earth and elements 3 and 4. The path including all these elements cannot be termed a connection, as has been decided in the application of Kendall, Serial No. 149,782, now patent No. 1,453,982, by the Examiners-in-Chief at page 7, lines 1 to 8, of their decision. The incidental path between the transformer winding and the source of current shown by applicant does not function as does Latour's connection and does not serve to keep these elements at the same potential as would a connection, as specified by the claim, because, in applicant's device, there is a potential drop across the elements 3 and 4 and also across the two ground connections which, even when well made, have considerable resistance. In the language of the Examiners-in-Chief, page 7, in the decision cited above, "in other words, there is nothing in the specification, as originally filed, to either suggest the features characterizing the" rejected "claims or that" applicant "then contemplated any such features or the advantages accruing therefrom".

Claims 1 to 37 and 39 are considered allowable.

As claim 38 has been twice considered by the examiner, and a clear issue has been reached, this action is made final. In accordance with the practice outlined in Ex parte Weber and Woodford, 254 OS 863, a time limit for appeal to the Examiners-in-Chief of thirty days from the date hereof is hereby set.

*H.M.*

*O. D. Baines*  
Exr. Div. 16

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Case

PART NO 27  
AMENDMENT

## UNITED STATES PATENT OFFICE.

Division 16 Room 112

Affdt  
Not entered

In re application of

HAROLD D. ARNOLD

Subject

Serial No. 568,285

POWER LIMITING AMPLIFYING  
DEVICE

Filed September 14, 1922

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

AUG 14 1923

Sir:

Responsive to the Office action of July 12, 1923,  
please amend this application as follows:

Page 1, line 2, cancel "East-Orange" and substitute  
--Maplewood--.

R E M A R K S

The change directed above cures this case from the  
objection of being informal.

Applicant is very reluctant to ask any further con-  
sideration of this case by the Examiner, and would not do so  
except for two things; first, that he feels that the Examiner  
has based his holding in part upon a slight misconception of  
the actual facts of the situation, and that a brief explana-  
tion of these facts at this point in the proceedings would  
be helpful; and secondly, that the Examiner in his second  
action raised points which had not previously been mentioned,  
and that applicant should be given an opportunity of reply-  
ing to the Examiner on these particular points rather than  
having to discuss them, in the first instance, before an  
appeal tribunal.



Accordingly the Examiner is respectfully asked to reconsider claim 36 and the question of applicant's right to make it, in view of the following.

The Examiner in the action of July 12, 1923, has based his adverse holding on four grounds. These are:

1. That whereas the patentee Latour shows a connection as a physical element of combination with a definite purpose to give a definite apparatus, applicant's grounding is not equivalent to an actual, tangible connection.
2. That the "path" which applicant shows includes a portion of earth and the elements 3 and 4. Examiner cites a decision by the Board of Examiners-in-Chief to support the holding that because of the ground and elements 3 and 4 included in this path, the path cannot be termed a connection.
3. That applicant's path does not function as does the patentee's connection.
4. The language of the decision referred to is adopted, stating that there is not in the original disclosure, any suggestion of the features claimed or that applicant then contemplated any such features or the advantages accruing therefrom.

It is particularly with regard to the first point, that applicant feels that the Examiner has gone rather far afield of the actual situation and of practical considerations. It is true that Arnold shows six different ground connections in his drawing, but it is unreasonable to suppose that any person who set out to build the apparatus according to Arnold's specification would actually provide six different binding-posts each marked "ground" and instruct users to make six separate connections to earth. The Examiner has taken too academic a view of a mere convention in the drawing. Any workman of even

Serial No. 588,285

--3.

ordinary skill would drive a single rod into the ground and connect all of the points shown grounded in the drawing to this single rod. This being so, even though applicant carried his appeal to the highest court and obtained an adjudication on the grounds urged by the Examiner to the effect that Latour's claim does not read on applicant's drawing, such a final decision could not be invoked in support of a non-infringement in the case of an actual embodiment of the system which Arnold shows, in an apparatus constructed as anyone in the trade would construct and use it. Hence a decision of this nature would be of no value whatever in practice.

The Examiner is asked to withdraw his holding of absence of physical connection in Arnold's showing, since the convention employed would at the time of filing the application mean to any workman of ordinary skill, that these grounded points are in an actual apparatus all to be connected together and to ground. The Examiner is also referred to the accompanying affidavit of Heising for the opinion of an expert in the art to which this application pertains.

As to the second point upon which the Examiner bases his holding, it is to be noted that the present case is quite different from that presented to the Board of Examiners-in-Chief in Kendall's appeal in Serial No. 149,782. There the applicant showed a path containing a battery and was attempting to claim a path of low impedance, the specification being silent on the impedance of the path. Here the question is whether or not a connection exists between two points in a circuit in such a sense as is within the fair meaning of a claim originating in another patent application and copied for purposes of interference. It is well settled that under



such circumstances the claim is to be given the broadest interpretation which it will bear in view of the prior art. In all such cases it is borne in mind that no two applicants will show identical embodiments and that a claim must always be construed with regard to equivalents. We have here the question of how broadly a claim may be interpreted to read on a different physical structure, whereas the Board, in Kendall's appeal, had to consider whether a limitation to specific properties of a path were warranted where the disclosure was in broad terms. Furthermore, there was no question of interference to influence the decision of the Examiners-in-Chief. Applicant contends that the proper guide for construing this claim is to be sought in Latour's disclosure, taken in the light of the prior art, and that only such limitations should be placed upon the claim as the patentee included or as the prior art requires.

It is found upon referring to the patentee's specification that he was perfectly general both in the description and claim. Nothing is found as to the impedance of his connection, the only emphasis being upon the points between which the connection is made, and as to this there is some latitude, for the connection may be made "to any point of the battery P, either to the positive pole or to the negative pole or to an intermediate cell as shown in dot and dash lines in Fig. 3" (page 4 of patent, lines 127-129). All that the claim specifies is "a connection" and this can only be taken to mean a physical connection of some kind.

This brings us to point 3 and to the question of whether the connection which Arnold shows is capable of functioning in the manner that Latour's connection is intended to function, that is, reduction of the singing tendency.

Serial No. 585,285

--3.

The accompanying affidavit of Heising is respectfully referred to as substantiating applicant's contention that under certain operating conditions, as explained in the affidavit, applicant's connection would secure the advantages pointed out by the patentee, and this is all that can be affirmed of Latour's circuit. It is thought that the affidavit will speak sufficiently clearly on this question, and without further comment we may pass to point 4 of the Examiner's holding.

This point is really related to point 2 and involves the question of whether applicant had any such purpose in mind, such as preventing ailing, by his particular mode of connection or whether he contemplated the advantages of his connection. As a general proposition of patent law the theory that an applicant must realize and have in contemplation the advantages inhering in his invention in order to lay claim to them cannot stand in view of such decisions as Briggs and Jacobi v. Kaisling. (Court of Appeals D.C.) 311 O.G. 3 (June 5, 1923) and Morgan Engineering Co. v. Alliance Machine Co. 176 F.2. 107. Both of these decisions are regarded as closely in point in the present case. They both, moreover, hold very clearly that contemplation of all of the advantages flowing from applicant's structure is no criterion of whether he invented the structure. In the light of these and other equally authoritative decisions, the fourth point mentioned above is clearly unsound in its application to the facts of this case.

Quoting from Briggs et al v. Kaisling:

"Even though the particular advantage had not been appreciated at the time, nevertheless, had it been an inherent function of the device as designed and constructed, the inventor could not have been deprived of it." (Page 4, lines 6 - 10).



Serial No. 568,265

-6.

Quoting from Morgan Engineering Co. v. Alliance  
Machine Co.:

"Moreover, as appears in the statement, it is expressly stated in claims 3, 4 and 5 of the letters patent that the hoisting-chains depend between the main and supplementary girders, and this fact is also displayed in Fig. 2 of the drawings. Even if the patentee at the time of making his application did not know of this advantage, or knowing failed distinctly to express it, he, in view of what he did state and show, is entitled to have his invention considered with reference to it. Indeed, the crane cannot be constructed and operated in accordance with the plain terms of his description without observing and securing this advantage." (Page 107, lines 11 - 20).

Applicant has established (1) that he has disclosed an actual physical connection between the points specified in the claim; (2) that this is a connection within the ordinary sense of the term as used in the claim; (3) that applicant's connection functions in a similar manner to the patentee's; and (4) that the practice as laid down by leading cases would amply warrant the allowance of this claim to applicant.

Reconsideration with allowance is requested.

Respectfully,

HAROLD D. ARNOLD,

By Ed. R. [Signature]  
Attorney.

463 West Street,

Low York, N.Y.,

Aug 9, 1923

H.B:BP

1095

#27

## UNITED STATES PATENT OFFICE

Division 16

Room 222

In re application of

HAROLD D. ARNOLD

Serial No. 586,285

Filed September 14, 1922

Subject:

POWER LIMITING AMPLIFYING  
DEVICE.

AUG 14 1923

AFFIDAVIT OF HEISING

RAYMOND A. HEISING, being duly sworn, deposes and says as follows:

I have been continuously in the employ of the Western Electric Company, Incorporated, serving in the capacity of Radio Engineer, since July, 1914, and during the entire period of my employment, down to and including the present, I have been engaged on problems involving high frequency generation, transmission, reception and the like.

I have considered the circuit shown in Fig. 3 of U. S. patent No. 1,405,525 to Latour dated February 7, 1922, and I have read his description of it. From my experience in the experimental and practical high frequency field, I am able to state that the connection shown in broken lines from the battery P to the primary winding of the transformer T<sub>1</sub> would not under all conditions of operation aid in reducing the singing tendency. Under some conditions, this connection would aid materially in reducing singing. The problem of eliminating singing or free oscillations in a complex circuit is not one which can be solved in a perfectly definite and straightforward manner by a method of precomputation on account of the large number of factors that can influence the development of such oscillations and the impossibility of predicting which influence will be of consequence. Given a drawing of a circuit such as the,



Affidavit of Heising:

-2-

patentee shows, it would be impossible for an expert to say a priori with assurance whether the circuit would sing or not. It is quite the general practice in setting up a new type of circuit to try different known expedients in order to determine experimentally which is the most effective means in the particular case. I am of the opinion that in some instances, the patentee would obtain different degrees of singing tendency dependent upon whether the connection from the battery P is made to the upper or to the lower terminal of the coil  $T_1$ . It is possible that in some conditions of operation, this connection might actually increase the singing tendency, but I am of the opinion that in the great majority of cases, such a connection would be advantageous in stabilizing the circuit against singing.

I have also inspected the drawing in application Serial No. 588,288 of Harold D. Arnold, originally filed September 3, 1915, renewed September 14, 1922, and am of the opinion that under many of the operating conditions in which Latour's connection would result in reducing the tendency to sing, it would be an inherent property of Arnold's circuit by virtue of the connection from the coil 2 to the antenna ground and thence to the grounds 60 and 61 to operate in the same manner to reduce singing.

It is a common tendency for amplifier circuits to sing at a frequency much higher than the frequency at which they are being operated. This tendency would no doubt be present in Latour's circuit. For frequencies high compared with the operating frequency Arnold's tuning condenser 3 would be practically impedanceless so that at the singing frequencies the potential across the condenser would in many practical cases have negligible effect on the singing tendency and would not prevent the stabilizing action of the connection

Affidavit of Neising:

--3.

to coil 2 from taking place.

I am of the opinion that the separate ground connections shown in Arnold's drawing, would, without the least question, be taken by a mechanic of ordinary skill in constructing circuits of this character to indicate that in practical apparatus only a single connection is actually to be made to earth and that the points shown as grounded are first to be connected together and then to ground.

Raymond A. Neising

Sworn to and subscribed before me

this 2<sup>nd</sup> day of August, 1923.

John Conrad  
Notary Public

NOTARY PUBLIC, Queens County  
Queens County Clerk's No. 1174  
Certificate filed in New York County  
Clerk's No. 136; Register's No. 4201  
Term Expires March 30th, 1924

H.B:EF



**INTERFERENCE.**Interference No. **49954**Paper No. **28**Name, **Harold de Forest Arnold.**Serial No. **588,285**; renewal of **48873**; filed **Sept. 3, 1915.**Title, **Power Limiting Amplifying Devices.**Filed, **Sept. 14, 1922.**Interference with **M. C. A. Latour.****DECISIONS OF**

Primary Examiner, \_\_\_\_\_

Dated, \_\_\_\_\_

Ex'r of Interferences, \_\_\_\_\_

*Int'ly Dissolved* Dated, *Dec-24, 1923*

Board, \_\_\_\_\_

Dated, \_\_\_\_\_

Commissioner, \_\_\_\_\_

Dated, \_\_\_\_\_

**REMARKS:**

This should be placed in each application or patent involved in interference in addition to the interference notice by Primary Examiner.

1099

Examiner of Interferences.  
Aug. 21, 1923.

Paper No. 29  
(REFERENCE.)

HSM:LBG

## DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C.

Mr. John G. Roberts,

463 West St.,

New York, N. Y.



Please find below a copy of a communication from the Examiner concerning the

Appl. of Harold de Forest Arnold, Ser. #588,285, filed Sept. 14, 1922  
Renewal of Ser. #48,873, filed Sept. 3, 1915.  
Power Limiting Amplifying Devices.

Very respectfully,

Room No. 122

ADDRESS ONLY  
THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.

THOS. E. ROBERTSON

Commissioner of Patents.

49954

The case, above referred to, is adjudged to interfere with others, hereafter specified, and  
the question of priority will be determined in conformity with the Rules.

The statement demanded by Rule 110 must be sealed up and filed on or before

NOV 26 1923

with the subject of the invention, and name of  
party filing it, indorsed on the envelope. The subject-matter involved in the interference is

1. In an amplifying apparatus for wireless signals and the like, a plurality of thermionic relays comprising each an evacuated bulb, a plate, a filament and a grid in said bulb, transformers having one of their windings in circuit with the filament and grid of each of said lamps respectively, the other winding of one of said transformers being adapted to be connected to a source of potential, a common source of current in circuit with the plate and filament of each of said relays, and a connection between said source of current and the transformer winding adapted to be connected to a source of potential.

The interference involves your application above identified; and

A patent, No. 1,405,523, granted Feb. 7, 1922, on  
application for Audion or Lamp Relay or Amplifying Apparatus,  
Serial No. 209,269, filed Dec. 28, 1917, by Marius C. A.  
Latour, whose postoffice address is 10 rue Auber, Paris,  
France, whose attorneys are Haseltine, Lake & Co., and whose  
associate attorney is H. W. Plucker, c/o Haseltine, Lake &



1100

Ser. #588,285 - 2.

Co., 15, Park Row (Suite 1632-1639), New York, N. Y.

The count of the interference is claim 38 of  
ARNOLD and claim 11 of LAFOUR.

asm.



Exr., Div. 16.

1101

Div. 16 Room 112

Address only  
The Commissioner of Patents  
Washington, D. C.  
and not any other by name.

Paper No. 2830

All communications respecting this  
application should give the serial number,  
date of filing, date of invention, and  
name of the applicant.

HSM:LBG

## DEPARTMENT OF THE INTERIOR

## UNITED STATES PATENT OFFICE

WASHINGTON

January 7, 1924

Mr. John G. Roberts,

463 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold de F. Arnold, Ser. #588,285, filed Sept. 14, 1922

Power Limiting Amplifying Devices.

*Thomas E. Robertson*

Commissioner of Patents.

This application comes before the examiner on the dissolution of the interference in which it was involved.

In view of applicant's admission and the decision in the interference, claim 38 stands finally rejected. Since, at the declaration of the interference, the prosecution of this case before the examiner was closed <sup>except</sup> as to matters arising out of the interference, this action is made final.

HSM

*A. O. Backus*

Exr., Div. 16.



MAIL ROOM  
JAN 19  
1924  
RECEIVED

## UNITED STATES PATENT OFFICE.

Division 15 Room 112

PAPER NO. 31  
AMENDMENT 2

In re application of

HAROLD G. F. ARNOLD

Subject.

Serial No. 388,285

Power Limiting Amplifying  
Devices

Filed September 14, 1922

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

RECEIVED  
JAN 21 1924

Sir:

In response to the Office action of January 7, 1924,  
please amend this application as follows:

Claim 34, line 5, change "simple" to --single--.

Cancel claim 38, and renumber claim 39 as 38.

R E M A R K S

This amendment cancels the claim finally rejected  
and corrects a typographical error in claim 34. The limita-  
tion in this claim was intended to be similar to that in  
claim 35, to a stage employing a single vacuum tube feeding  
into the push-pull stage.

An allowance is requested.

Respectfully,

HAROLD G. F. ARNOLD

By John H. ...  
Attorney

463 West Street,

New York,

JAN 18 1924

MAIL ROOM

HAROLD

DIV. 76

1914

(EXR'S BOOK) 214-3

NUMBER (Series of 1909).

841568

PATENT No. 1129942

Name *Harold R. Forest Arnold*  
*Assoc to Western Electric Company,*  
*New York, N.Y., a corp of Ill.*

*East Orange*

County of

State of

*New Jersey*

Invention

*Gascons Repeaters in Circuits of Low Impedance.*

ORIGINAL

RENEWED

Petition	<i>May 28, 1914</i>	191
Affidavit	<i>June 1, 1914</i>	191
Specification	<i>June 1, 1914</i>	191
Drawing <i>2 sheets</i>	<i>June 1, 1914</i>	191
Photo Copy	<i>June 4, 1914</i>	191
First Fee Cash	<i>May 28, 1914</i>	191
" " Cert	<i>May 28, 1914</i>	191
Appl. filed complete	<i>May 28, 1914</i>	191

Examined and Passed for Issue *Oct 8, 1914*

*W. A. Kinnear, Jr. Dis. 16*

Notice of Allowance *Oct. 13, 1914*

Final Fee Cash *Oct 13, 1915*

" " Cert *Oct 13, 1915*

Patented *March 2, 1915*

Attorney *De Witt C. Jones & John Roberts*

*463 West St. New York, N.Y.*

Associate Attorney

(No. of Claims Allowed *7*) Title as Allowed *Gascons Repeaters in Circuits of Low Impedance.* 179-171



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25 TO ALL WHOM IT MAY CONCERN:

26       It is known, that I, HAROLD D. FORREST ARNOLD, a  
27 citizen of the United States, residing at East Orange, in  
28 the County of Essex and State of New Jersey, have invented  
29 certain new and useful improvements in Gaseous Repeaters  
30 in Circuits of Low Impedance, of which the following is a  
31 full, clear, concise, and exact description.

32       This invention relates to the use of repeaters generally.

1 and of vacuum discharge repeaters more particularly, as  
2 amplifiers without transformers. Still more particularly,  
3 it relates to the use of thermionic repeaters for securing  
4 amplification of current in circuits of low impedance. By  
5 a thermionic current is meant current discharge from a hot  
6 cathode. Examples of thermionic repeaters are the DeForest  
7 audion disclosed in patent No. 879,532, dated February 18,  
8 1914, and others, the Von Leiben & Riess repeater disclosed  
9 in patent No. 1,058,910, dated September 17, 1912, etc. By  
10 vacuum discharge is meant current discharge between electrodes  
11 in space from which nearly all atmosphere is exhausted. The  
12 expression vacuum discharge repeaters is intended to include  
13 repeaters of the thermionic types and also those in which  
14 current flows between electrodes in space maintained in a  
15 conductive state by the arc or otherwise. The mercury arc  
16 repeater of an earlier application of this applicant, Serial  
17 No. 709,445, filed July 13, 1912, is an example of the class  
18 of vacuum discharge repeaters but it is not of the thermionic  
19 type.

20 In many instances it is necessary or desirable,  
21 for securing the best results, to exclude transformers from  
22 the circuit. Such is the case, for example, in those cir-  
23 cuits in which the frequency is so low that efficient trans-  
24 formers are costly and difficult to design, as is the case  
25 in telegraph circuits in general and especially in submarine  
26 and wireless telegraph circuits. It is particularly de-  
27 sirable to exclude transformers from circuits in which an  
28 exact reproduction of wave form is necessary for legibility,  
29 as, for example, in submarine cable circuits. It is also  
30 desirable to exclude transformers from circuits in which un-  
31 distorted amplification must be secured over a wide range of  
32 frequencies, as, for example, in the reproduction of speech.



1 and music.

2 Heretofore it has been necessary to employ trans-  
3 formers in circuit with the audion in order to secure ef-  
4 ficient amplification of current by the audion, and this is  
5 especially true where the amplification is desired in circuits  
6 of low impedance. This is due to the fact that the impedance  
7 of the input circuit of an efficiently operating audion is  
8 very high, at least 100,000 ohms and in general as high as  
9 10 megohms. Hence, in a circuit of low impedance, if no trans-  
10 former is used, the larger part of the possible current ampli-  
11 fication by the audion is lost. For example, if the impedance  
12 of the input circuit of the audion is only 100,000 ohms and the  
13 input circuit of the audion be connected, without the use of  
14 transformers, in a line of 1000 ohms impedance, at least 90%  
15 of the possible current amplification is lost.

16 Moreover, in the case of audions of the prior art,  
17 the impedance in the output circuit of the audion is always so  
18 great that a considerable additional loss of possible ampli-  
19 fication must occur if the output circuit of the audion is  
20 directly connected to a circuit of low impedance.

21 It has been discovered that audions of the usual  
22 type may be so constructed that, without the use of trans-  
23 formers, they will step up the input voltage of either direct  
24 current or alternating current of any frequency in one step  
25 to as much as 30 times its original value, or in two successive  
26 steps to as much as 500 times its original value. The voltage  
27 amplification thus secured is entirely free from wave distor-  
28 tion whatever may be the initial frequency and wave form.  
29 This type of audion will, for convenience, be hereinafter  
30 referred to as the high-voltage output audion.

31 It has furthermore been discovered that audions may  
32 be constructed which will step down the input voltage, for

1 example, to one-third of its original value. This last  
 2 mentioned type of audion has a high current and a low voltage  
 3 output. Because of its low output impedance, such type of  
 4 audion can be worked efficiently into a line of like impedance.  
 5 This new type of audion will, for convenience, hereinafter  
 6 be referred to as the high-current output audion.

7 The structures which will provide the greatest  
 8 degree of efficiency in the above mentioned different types  
 9 of audions form the subject-matter of a copending application  
 10 of even date herewith.

11 It has been discovered that a combination of one  
 12 or more of the aforementioned high-voltage output type of  
 13 audions working into one of the high-current output type, will  
 14 operate, without transformers, from a line of low impedance,  
 15 for example, 250 ohms, into a like line with a resultant  
 16 current much greater, fifty or more times greater, than  
 17 would flow in the second circuit if it were directly connected  
 18 to the first circuit. (The present invention is directed to  
 19 such combination of two different types of repeaters, preferably  
 20 audions. A system designed to secure the same result and em-  
 21 ploying a large number of the high-voltage output type of  
 22 audions connected in multiple and working into a common output  
 23 circuit in lieu of a single audion of the high-current output  
 24 type, forms the subject-matter of still another application  
 25 for patent of even date herewith.

26 The present invention may be more readily under-  
 27 stood by reference to the accompanying drawings in which  
 28 (Fig. 1 is a view in perspective of an audion of  
 29 the high-voltage type;

30 Fig. 2 is a similar fragmentary view of an audion  
 31 of the high-current output type;

32 Fig. 3 is a similar fragmentary view of the two



1 different types of audions embodied in a unitary structure;

2 Fig. 4 shows a circuit arrangement embodying this  
3 invention in which a plurality of audions of the high-  
4 voltage type in tandem work into an audion of the low-voltage  
5 type;

6 Fig. 5 shows a simplified circuit arrangement  
7 giving the same result as in Fig. 4;

8 Fig. 6 shows a still further modification more  
9 particularly applicable to telephone circuits;

10 Fig. 7 shows a plurality of audions of the high-  
11 voltage type in tandem working into a plurality of audions  
12 of the ~~low-voltage~~ <sup>high current output</sup> type, each of the latter feeding into a  
13 separate output line; and

14 Fig. 8 shows a circuit arrangement embodying the  
15 invention in which the two different types of audions are  
16 combined in one bulb.

17 Like reference characters refer to like parts  
18 throughout the several views.

19 In the drawings, the audions 1 are of the high-  
20 voltage output type and the audions 2 are of the high-current  
21 output type. In the former type, the input electrode may  
22 be in the form of a grid, preferably made of very fine wire  
23 with a fine mesh or the like, and the output anode or plate 4  
24 is placed at a considerable distance from the cathode which  
25 is preferably a filament 3, as shown. The filament need not  
26 present a large active area. The filament, grid and plate are  
27 as usual sealed in an evacuated bulb 5. In order to secure  
28 best results in this type of audion, the grid should be near  
29 the filament, the plate should be distant from the filament,  
30 and the grid should present a finely meshed or discontinuous  
31 surface between the filament and the plate.

32 In the high-current output type of audion, the

1 input electrode or grid 7 may be at any side of the filament  
2 and should have a coarse mesh or preferably consist merely of  
3 a short length of wire. The output electrode or plate 8 is  
4 placed as near to the filament 9 as is conveniently possible.  
5 The filament preferably presents a large, active area. The  
6 filament, grid and plate are as usual sealed in an evacuated  
7 bulb 10. In order to secure the best results in this type  
8 of audion, the grid and plate should both be near the filament,  
9 the filament area should be large, and the grid should present  
10 the least possible obstruction between the filament and plate.

11 As hereinbefore stated, the high-voltage output  
12 type of audion gives an amplification with low current and  
13 high voltage in its output circuit; whereas the high-current  
14 output type gives amplification with high current and low  
15 voltage, and hence low impedance, in its output circuit.

16 In Fig. 4, two high-voltage output audions 1, 1  
17 connected in tandem are shown working into a high-current  
18 output audion 2. The batteries 11 are preferably of such  
19 value as to make each of the grids 3, 3 and 7 normally about  
20 five volts negative with respect to its adjacent filament.  
21 The several filaments are heated by the respective batteries  
22 12. The output circuit of each audion includes its plate, a  
23 high resistance 14, a battery 13 and the filament of the audion.  
24 The resistance 14 should be, for example, 100,000 ohms or more.  
25 The input circuit of the first audion of the group is directly  
26 connected to the input line 15. The input voltage on the  
27 grid of the first audion 1 causes an increase in the voltage  
28 of the current flowing in the output circuit of said audion,  
29 thereby developing a voltage change on the grid of the next  
30 audion of the series, and so on. As a result of such con-  
31 struction and arrangement of these audions, the voltage in  
32 the input circuit of the second of the two audions in tandem



1 is much greater than that impressed upon the first, although  
 2 the current in the interconnecting circuit is small. The  
 3 audion 2 acts as an amplifier in which the current is increased  
 4 and the voltage lowered in its output circuit. Because of  
 5 the fact that the impedance in the output circuit of the  
 6 audion 2 is lowered, it can be worked efficiently into a  
 7 line 16 of low impedance. It has been found, for example,  
 8 that the amplifying means shown in Fig. 4 will work from an  
 9 incoming line of 250 ohms impedance into an outgoing line of  
 10 like impedance with a resultant current of more than fifty  
 11 times that which would flow in the outgoing line if the latter  
 12 were directly connected to the incoming line.

13 Fig. 5 shows a simplification of the system il-  
 14 lustrated in Fig. 4, in that a common battery 12 furnishes  
 15 current to all the filaments, said filaments being connected  
 16 in series with the battery, and a common battery 13 serves for  
 17 all of the plates.

18 Fig. 6 shows a further simplification of the system  
 19 illustrated in Fig. 5. An impedance coil 17 is included in  
 20 bridge of the output circuit of each audion, and in the output  
 21 circuit of the two audions 1, 1, condensers 18, 18 are inserted  
 22 in series with the resistances 14. By such arrangement the  
 23 several batteries 11 may be largely reduced in voltage.  
 24 This arrangement is particularly applicable to embodiment in  
 25 a telephone system.

26 Fig. 7 shows a plurality of the high-voltage output  
 27 audions in tandem working into a plurality of the high-current  
 28 output audions, each of the latter working into its own output  
 29 circuit 19, 20 or 21. Otherwise, the circuit arrangement is  
 30 substantially that shown in Fig. 5. The arrangement shown  
 31 in Fig. 7 is particularly applicable to the operation of  
 32 several loud-speaking receivers from a common talking circuit.

Fig. 8 shows a structure and circuit arrangement in which an audion of the high-voltage output type works into an audion of the high-current output type, the two audions being contained in a single bulb and operating from a common filament having one branch 5 for the audion 1 and another branch 9 for the audion 2. The input electrode 7 of the audion 2 is shown in the form of a short length of wire. The circuit arrangement is substantially that illustrated in Figs. 4 and 5, and further description thereof is deemed unnecessary. This structure and arrangement have been found to operate successfully, without the interposition of transformers, between lines of the impedance of ordinary telephone lines.

As applied to submarine cable work for amplifying the feeble current at the receiving end the invention is of special importance. The large amplification attained makes it possible to operate over such cables at greatly increased speed. Furthermore, less delicate recording devices will suffice as a substitute for the ordinary siphon recorder. Moreover, the high amplification secured renders possible the direct repetition from one section of a cable to another or from submarine to land telegraph lines. The invention is also particularly adapted for use in circuits where especially pure, loud reproduction of speech or music is desired. In general in the art of submarine, land and wireless telegraphy, the invention is of importance with reference to recording, high-speed working and direct repetition from one type of system to another type of system.

46



What is claimed is:

1. The combination with a repeater having a characteristic current and voltage output, of a second repeater into which the first mentioned repeater works, said second repeater having a different current and voltage output.

2. The combination with a repeater having a low-current and high-voltage output, of a second repeater into which said first mentioned repeater works, said second repeater having a high-current and low-voltage output.

3. The combination with a vacuum discharge repeater having a low-current and high-voltage output, of a second vacuum discharge repeater into which said first mentioned repeater works, said second repeater having a high-current and low-voltage output.

4. The combination with a source of feeble electric currents, of a thermionic repeater having an input circuit directly connected to said source of current and an output circuit of high voltage, and a second thermionic repeater having an output circuit of low impedance and having an input circuit directly connected to the output circuit of said first mentioned repeater.

5. The combination with a plurality of repeaters having a low-current and high-voltage output, of a repeater having a high-current and low-voltage output, and a system of circuits connecting said repeaters in tandem.

6. The combination with a plurality of repeaters connected in tandem, the first repeater of the series having a high-voltage output and the last repeater of the series having a high-current output.

7. The combination with a plurality of thermionic repeaters connected in tandem, the first repeater of the series having a high-voltage output and the last repeater of

the series having a high-current output.

8. The combination of a plurality of thermionic repeaters connected in tandem, the last repeater of the series having a high-current and low-voltage output.

9. The combination with an incoming and an outgoing line of low impedance, of a plurality of repeaters in tandem, the first of said repeaters having a high-voltage output and the last of said repeaters having a high-current output, and the first of said repeaters having its input circuit directly connected to said incoming line, and the last of said repeaters having its output circuit directly connected to said outgoing line.

10. The combination with an incoming and an outgoing line of low impedance, of a plurality of thermionic repeaters in tandem, the first of said repeaters having a high-voltage output and the last of said repeaters having a high-current output, and the first of said repeaters having its input circuit directly connected to said incoming line, and the last of said repeaters having its output circuit directly connected to said outgoing line.

11. The combination with a line of low impedance, of a current amplifying means directly connected thereto, said amplifying means comprising a plurality of repeaters in tandem, the first of said repeaters having a high-voltage output and the last of said repeaters having a high-current output.

12. The combination with a line of low impedance, of a current amplifying means directly connected therewith, said amplifying means comprising a plurality of thermionic repeaters in tandem, the first of said repeaters having a high-voltage output and the last of said repeaters having a high-current output.



1111°

13. The combination with a repeater, of a plurality of vacuum discharge repeaters connected in multiple with the output circuit of said first mentioned repeater, said first mentioned repeater having a high-voltage output and said other repeaters each having a high-current output.

14. The combination with a thermionic repeater, of a plurality of thermionic repeaters connected in multiple into which said first mentioned repeater works, said first mentioned repeater having a high-voltage output and said other repeaters having a high-current output.

15. The combination of two thermionic repeater structures connected in tandem and having a common enclosing bulb, the first of said structures having a high-voltage output and the other a high-current output.

Sigs.

GKF-DG

In Witness Whereof, I, \_\_\_\_\_ hereunto subscribe my  
name this 25 day of May, A. D. 1914.

WITNESSES:

E. E. E.  
W. L. S.

Harold DeForest Arnold

State of NEW YORK

COUNTY OF NEW YORK

ss.

HAROLD DeFOREST ARNOLD

\_\_\_\_\_, the above named petitioner,  
being duly sworn, deposes and says that he is a \_\_\_\_\_ citizen  
of the United States, and resident of \_\_\_\_\_ East Orange \_\_\_\_\_ in the  
County of \_\_\_\_\_ and State of \_\_\_\_\_ New Jersey \_\_\_\_\_  
and that he \_\_\_\_\_ verily believes himself \_\_\_\_\_ to be the  
original, first, and sole \_\_\_\_\_ inventor of the improvement in \_\_\_\_\_  
\_\_\_\_\_ Caseous Repeaters in Circuits of Low Impedance \_\_\_\_\_

described and claimed in the annexed specification; that he \_\_\_\_\_ does not  
know and does not believe that the same was ever known or used before  
his \_\_\_\_\_ invention or discovery thereof; or patented or described in any  
printed publication in the United States of America or any foreign country  
before his \_\_\_\_\_ invention or discovery thereof or more than two years prior  
to this application; or in public use or on sale in the United States for more  
than two years prior to this application and that no application for foreign  
patent has been filed by him \_\_\_\_\_ or his \_\_\_\_\_ legal representatives or  
assigns in any foreign country.

Harold DeForest Arnold

Sworn to and subscribed before me }  
this 25 day of May 1914 }

E. E. E.

Notary Public.



1116

DEPARTMENT OF THE INTERIOR  
 UNITED STATES PATENT OFFICE

WASHINGTON

July 31, 1914.

Mr. John G. Moharta,

462 West Street,

New York, N. Y.

PATENT OFFICE  
 JUL 31 1914  
 MAILED

Please find below a communication from the EXAMINER in charge of the

H. DeF. Arnold, S. No. 841,868, filed May 28, 1914.

Gaseous Repeaters in Circuits of Low Impedance.

This application has been examined.

Claims 1, 2, 3, 5, 6, 8, 9 and 11 are rejected on the patent to Warth, 980,458, June 7, 1910, 179 - 170. In this patent two different types of relays or amplifiers are connected in tandem so that the out-put circuit of the first works into the in-put circuit of the second. The two amplifiers have entirely different characteristics. The first amplifier consists of an electromagnet C having control of microphone elements A and g which are of extremely small mass so as to be easily operated by weak currents. The second electromagnet C' is polarized and actuates a granular carbon resistance cup. It is clear that the voltage and current out-put of the first circuit is different from the voltage and current out-put of the second amplifier. It might very well be that the amplifier g would produce a high voltage of current flow while the amplifier C' would produce a low voltage but a high current flow. In this system this would be a mere matter of proportioning the parts. Consequently it is be-

841,568 -- 2.

lieved that the claims do not define over this system.

Claim 8 is rejected on the ground that it involves merely connecting a plurality of audions in tandem. This would be suggested by deForest, 995,126, June 13, 1911, 179 - 171. The statement that the last repeater has a high current low voltage out-put does not define over the ordinary audion as what is high and what is low is merely relative, and so far as the claim is concerned it comprises merely a plurality of audions all having the same characteristics and hence does not properly define applicant's invention.

Claims 4, 7, 10 and 12 to 15, inclusive, appear to be allowable as at present advised.

Attention is further called to French patent, 377,413, Sept. 6, 1907, 179 - 171, and Lindridge, 1,047,956, Dec. 24, 1912, 179 - 171.

*Wm A. Kruman*  
Examiner, Division XVI.



1118

SEP 11 1914

PAGE 2 NO 3  
AMENDMENT A

UNITED STATES PATENT OFFICE  
Division 16 - Room 109

In re application of )  
H. DeF. Arnold, ) Gaseous Repeaters in  
Serial No. 841,568, ) Circuits of Low Impedance.  
Filed May 28, 1914. )

COMMISSIONER OF PATENTS:

Washington, D.C.

Sir:

In response to the Office action of July 31, 1914,  
please amend the above entitled application as follows:

Erase claims 1, 2, 3, 5, 6, 8, 9 and 11, and re-  
number the remaining claims accordingly.  
✓ Claim 1 (original 4), line 2, change "or" to --of--.

REMARKS

It is believed that applicant's invention is amply-  
covered by the claims allowed, and the application has therefore  
been amended by compliance with the Office rejection of the  
remaining claims. It is noted that the Warth patent does not  
disclose a system which is at all adapted for the purposes  
of applicant's invention. The statement in the Office  
action, therefore, that in this patent it might be that one  
amplifier would produce a high voltage, while the other amplifier  
would produce a low voltage and high current, is objected to.  
What might have been disclosed in this reference should not be  
considered as affecting applicant's right to claims on his  
disclosure.

Respectfully,

H. DeF. ARNOLD,

By

*J. Roberts*

Attorney

465 West Street,

New York, September 10, 1914.

OCR-R

DOCKET CLERK

OCT 16 1914

OFFICE

1119

PAPER NO. 1  
AMENDMENT

1119

UNITED STATES PATENT OFFICE  
Division 15, Room 109

In re application of  
Harold DeForest Arnold  
Serial No. 841,568  
Filed May 23, 1914...

Gaseous Repeaters in  
Circuits of Low Impedance

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

Please further amend this case as follows:

✓ Page 4, line 9, after "application" insert --in my  
name, Ser. No. 841,567 filed--; same page, line 24, after  
"type" insert a comma; same page, line 25, after "patent"  
insert --in my name, Ser. No. 841,569 filed--; same page,  
line 29, after "high-voltage" insert --output--; line 31,  
change "low-voltage" to --high-current output--.

✓ Page 5, line 12, change "low-voltage" to --high-  
current output--.

Respectfully,

HAROLD DEFOREST ARNOLD,

By S. J. Hanne

Attorney

463 West Street,

New York, October 7, 1914.

Approved

The proposed corrections being  
merely format, it is recommended that  
this amendment be entered under Rule  
75, without withdrawing the case from  
issue. The final fee has not been paid.

W. K. Kinsman  
Exam. in Charge

OCT 19 1914

R. F. Whitehead

6547



**BLANK**

**PAGE**

MAKER (Series of 815)

59210

1915

(EXR'S BOOK)

ABANDONED

72-10

Div. # 5-1

PATENT No.

*Harold DeForest Arnold*  
*Electric Company, of New York, N.Y.,*  
*corp. of Illinois New York.*

*East Orange*

County of

State of

Invention

*New Jersey*  
*Thermionic Devices and Methods*  
*of Constructing and Operating the Same*

ORIGINAL

REPRODUCED

Position

*Nov 2, 1915*

Affidavit

*11 11 1915*

Specification

*9 6 1915*

Drawing

*24th 11 11 1915*

Photo Copy

*July 24 1916*

First Fee Cash

*15 Nov 2 1915*

" " Cont.

*191*

Appl. filed complete

*Nov 2, 1915*

Drawings and Patent for Exam.

*191*

Exp. Dnr.

Notice of Allowance

*191*

Final Fee Cash

*191*

" " Cont.

*191*

Patented

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1 This invention relates to thermionic devices and  
2 a method of operating the same. Its object is to provide  
3 for the operation of such a device by means of a current  
4 carried only by those negative corpuscles, or electrons,  
5 which are emitted from <sup>a</sup>the heated cathode; in particular  
6 to insure that no other carriers of electricity shall be  
7 furnished by gas ionization taking place in the region  
8 between the cathode and the anode under those conditions  
9 of operation which are contemplated.

10 This object has been accomplished by such design  
11 and preliminary treatment of the evacuated vessel with  
12 its contained electrodes that, for the contemplated  
13 method of operation, the number of ionizable gas or  
14 vapor molecules remaining as an unavoidable residue  
15 after evacuation and other treatment or liberated in  
16 the operation of the device, shall be so small that  
17 those struck by electrons having the requisite ioniza-  
18 tion energy shall not contribute more than a negligible  
19 part (after ionization) to either the distribution or  
20 absolute value of current or volume density of charge  
21 between the electrodes.

22 By this means are secured certain important  
23 advantages in operation which could not be obtained  
24 in previous devices of this general type, notably,  
25 for example, the ability to so control the electron  
26 current, by the use of an auxiliary electrode, that  
27 changes so produced in such current <sup>shall</sup> be accurate and amplified  
28 copies of the controlling voltage, with no tendency toward  
29 instability and its resultant disturbances which destroy the  
30 fidelity of the copy.

31 This invention will be described more fully in connection  
32 with the drawings, in which Fig. 1 represents diagrammatically

1 a form of thermionic device, showing only the essential  
2 features of a typical thermionic device; Fig. 2 is a  
3 curve which will be used to explain the operation of  
4 thermionic discharge tubes, both with and without gas  
5 ionization; Fig. 3 shows a form of thermionic repeater  
6 which has been found to be successful in telephony,  
7 together with its circuit; Fig. 4 shows an amplifier  
8 designed to handle <sup>larger</sup> amounts of power, at higher voltages,  
9 than is necessary or desirable in the case of the telephone  
10 repeater; and Fig. 4<sup>a</sup> shows this amplifier associated with  
11 an antenna in a radio transmission system. In this figure  
12 for the sake of clearness, a simplified diagram of the  
13 amplifier of Fig. 4 is shown.

14 Referring to Fig. 1, 1 represents a cathode which,  
15 when heated by current from the battery 5, emits electrons  
16 in the manner now well known, and 2 is an anode to which the  
17 emitted electrons may be driven. These two elements are  
18 enclosed in a vessel 3, which is exhausted. Battery 4, of  
19 electromotive force  $V$ , is connected between the elements 1  
20 and 2 so as to make 1 the cathode. When the cathode is  
21 maintained at a temperature sufficiently high it emits  
22 electrons, and by virtue of the electric field established  
23 between anode and cathode, these emitted electrons tend to  
24 be driven to the anode; whether they actually reach the  
25 anode, or are returned to the cathode, depends upon the  
26 voltage and the temperature. The number of electrons  
27 emitted from a cathode depends upon its area, material and  
28 temperature, while the number of these latter which move to  
29 the anode, forming the electron current, depends upon the  
30 strength of the electric field in the tube, and the latter is  
31 determined, for a given tube, both by the voltage of the  
32 battery and by the number of electrons in the space, as will



1 be more fully described later.

2 Referring to Fig. 2, which is a curve showing the  
3 relation between the current (I) through the tube and the  
4 voltage (V) applied between anode and cathode, the full line  
5 curves show the performance of a thermionic device in which  
6 the carriers are electrons from the cathode no other  
7 ions being present. The reason the curve has this  
8 particular form is as follows:

9 Suppose that the temperature of the cathode is  
10 raised to its operating value, the battery being discon-  
11 nected. The cathode then begins to emit electrons at a  
12 rate which depends upon the temperature. The emitted  
13 electrons are projected out into the space around the  
14 cathode, and consequently produce a negative volume charge  
15 throughout that region; but this negative charge tends to repel  
16 further electrons coming from the cathode, and in a very  
17 short time after the temperature has been raised so many  
18 electrons have been thrown into the space that other electrons  
19 leaving the cathode are forced back to it as fast as they  
20 are emitted. An equilibrium is thus set up in which the volume  
21 density of electrification is constant and just sufficient  
22 to set up that electric field intensity at the cathode which,  
23 on the whole, will prevent more electrons leaving it; that  
24 is, in this condition as many electrons are returned to the  
25 cathode as are emitted from it.

26 Now suppose the battery is connected, thus establishing  
27 in the tube an electric field tending to draw electrons  
28 toward the anode. The electrons making up the volume density  
29 mentioned above will be drawn to the anode, other electrons  
30 from the cathode take their places, and a current will begin  
31 to flow in the tube. At this stage the cathode is capable of  
32 furnishing many more electrons than are drawn to the anode.

1 but is prevented from doing so by the repulsion of the  
2 electrons already in the field. The impressed voltage tends  
3 to overcome this repulsion, and, as the voltage increases,  
4 the current does also, as indicated by the part A of the  
5 curve. As the voltage becomes larger the retarding field  
6 which is due to accumulated electrons, exerts relatively  
7 less influence, and the current increases more rapidly,  
8 as at the part B. These two parts are, of course, not  
9 separate, being portions of the same curve, which, in  
10 practical devices, approximates closely to a parabola.

11 This process continues with increasing applied  
12 voltage until a point is reached at which nearly all the  
13 electrons which can be emitted by the cathode, at the  
14 given temperature, are drawn away from it and toward  
15 the anode. The curve then bends over, as at C, and with  
16 still larger voltages all of the electrons which can be  
17 emitted from the cathode are drawn away. At this stage,  
18 corresponding to the part D in the drawing, no further  
19 current can flow from the cathode, no matter how large  
20 the impressed voltage may be. This is called the saturation  
21 current for the given conditions. This is the curve  
22 which would be obtained were it possible to remove all  
23 sources of carriers of electricity except the hot electron-  
24 emitting cathode.

25 If the temperature of the cathode, instead of being  
26 maintained at the value assumed in the preceding discussion,  
27 is raised to a higher value, another curve  
28 (OABJK of Fig. 2) is obtained with no gas ionization. In  
29 this condition of operation more electrons may be drawn  
30 away at any given voltage, and larger currents will be  
31 obtained.

32 The form of either of these curves, before they begin



Part

to bend over as at C or C', and when all the carriers are of one kind as is the case here, was first derived explicitly by C.D. Childs (Phys. Rev., vol. 32, pages 492-511, 1911), who also pointed out explicitly the retarding effect of the carriers making up the volume charge above referred to. His equation shows that in simple cases the curve is of the form

$$I = AV^{3/2}$$

in which A is a constant which depends upon the form of the tube and the physical constants of the carriers. It has been found that, in practical devices employing an extended cathode which is not an equipotential surface, the exponent of V is more nearly 2.

Now suppose a small quantity of ionizable gas or vapor is present, as must be the case in any actual device, since it is obviously impossible to remove all gases and vapors. Whenever a molecule of such gas or vapor is struck by an ion having sufficient kinetic energy, the molecule will be split into a positive and a negative part, that is, it will be ionized by collision. In order that this shall happen it is necessary that the striking ion shall have fallen freely through a certain potential difference, between collision with neutral molecules, of from 4 to 21 volts, depending upon the nature of the gas. It will be clear that, whenever such a collision takes place, carriers of electricity are produced in the space between the electrodes as well as at the cathode, and since carriers of both signs are produced, some will travel toward the anode and some (the positive) toward the cathode. But these new carriers may themselves produce additional ions by collisions, whenever they happen to strike, with sufficient energy, molecules of gas, and therefore, when ionization by collision takes place, it

1 results in an increase in current, which, with a further  
2 increase in applied voltage, <sup>may rise</sup> ~~rise~~ suddenly to a relatively  
3 large value. In this condition it has been found that the  
4 tube is extremely sensitive to changes in external and in-  
5 ternal conditions, and that it is unstable in operation.

6 The value of applied voltage at which this effect  
7 starts, and at which the operation of the tube begins to be  
8 unstable, depends upon the number of gas molecules in the  
9 *and occluded in the electrode, inner tube walls, etc.* space; in other words, there is a certain definite relation  
10 between the number of gas molecules in the tube and the  
11 number and speed of the electrons from the cathode, which  
12 determines whether or not there will be appreciable current  
13 increase due to gas ionization. This current rise will occur  
14 when the gas molecules are so numerous that the number of  
15 new ions formed by collision becomes appreciable in com-  
16 parison with the number of electrons passing from the  
17 cathode to the anode. Since the electrons will have  
18 greater speed and energy the greater the applied voltage,  
19 it is clear that fewer gas molecules are permissible, other  
20 things being the same, the larger the applied voltage;  
21 for example, in Fig. 2 the dotted portion E of the curve  
22 ~~represents~~ represents the manner in which the operation with no  
23 residual gas is modified when a small number of gas  
24 molecules is present. If this number is increased, the  
25 current rise will occur at some other part F of the curve,  
26 corresponding to a lower voltage. If still more molecules  
27 *or are readily liberated in the tube* are present, the instability may begin at and proceed along  
28 the dotted part G.

29 Now, in using as an amplifier a thermionic device having  
30 an auxiliary electrode or grid, it is desirable to operate at the  
31 part B of the curve, where the characteristic curve is approximat  
32 straight and rising, because within this range amplification



1 takes place without distortion. For such use, therefore,  
 2 the gas density must be so small that there shall occur no  
 3 ionization producing a condition such as that typified by  
 4 the dotted curve G. If the gas is so far eliminated that  
 5 the current rise takes place along F or E for example,  
 6 no trouble will be experienced at the point B. It will, of  
 7 course, be desirable to so treat the tube that the current  
 8 rise E or F) shall occur at voltages enough higher than  
 9 the operating voltage ( $V_1$ ) to insure a reasonable margin  
 10 of safety for those accidental increases in voltages or  
 11 changes in vacuum which are likely to occur in practice.

12 If the temperature of the cathode is so adjusted  
 13 *Qia* that the upper curve <sup>K</sup> of Fig. 2 is obtained, and if the  
 14 operation as an amplifier is to take place on the steep  
 15 and approximately straight part J of this curve, it will be  
 16 *take somewhat better prepared to hold it*  
 17 clear that a ~~somewhat better~~ vacuum will be necessary to  
 18 secure the same margin of safety as in the case of operation  
 19 at the corresponding point B of the lower curve, because the  
 20 operating voltage and the number and kinetic energy of  
 21 the electrons are greater at the higher temperature than  
 22 at the lower.

23 On the other hand, if the device is to be used as a  
 24 detector, that is, depending upon the rectification of the  
 25 currents produced by small variations in voltage, it is  
 26 necessary to operate at a point at which the characteristic  
 27 is curved, for no rectification can be effected on a straight  
 28 characteristic by producing changes in the applied voltage.  
 29 This is because, using a straight characteristic, a positive  
 30 increment of voltage, added to the normal operating voltage,  
 31 produces the same change in current as does an equal negative  
 32 increment, and the average change in current is therefore zero;  
 33 while if the slope of the characteristic is changing in the

1 neighborhood of the normal operating voltage, the effects  
2 due to such increments are not equal, and an average  
3 current different from zero is obtained. For the purpose  
4 of detecting small oscillations, such as occur in wireless  
5 telegraphy, it may therefore be desirable to utilize the  
6 curve QAO, which is obtained when much more gas is present  
7 than could be tolerated in an amplifier. In that case,  
8 the detector could be operated at the point H where the  
9 curvature, due to impending instability, is considerable.  
10 In this case it will, of course, be necessary to maintain  
11 accurate adjustment of applied voltage to guard against  
12 excessive ionization, or "fuzzing" in the tube. This was the  
13 condition of operation of the original DeForest audion, as  
14 a detector, and it introduced troubles due to excessive  
15 ionization when the attempt was made to employ it in  
16 telephone circuits, in which the changes in voltage are  
17 much larger.

18 It has been found that the device may be used efficiently  
19 as a detector, without the use of gas ionization and  
20 consequent instability, by operating on a curved part  
21 (A or C) of the curve of Fig. 2.

22 A further disadvantage resulting from allowing  
23 appreciable gas ionization is that the positive carriers  
24 so produced may be drawn to the cathode with sufficient  
25 energy to break it down.

26 The fact that electrons emitted from a heated filament  
27 will act, without gas ionization, to carry the current  
28 between the cathode and the anode, has long been a matter  
29 of scientific knowledge, but prior to this invention, so far  
30 as is known, no practical advantage had been taken of  
31 this fact. It has been commonly supposed that the electrons  
32 thus emitted must be utilized to ionize the residual gas in



1 the vacuum tube in order that the device might operate  
 2 efficiently. The DeForest audion, according to the printed  
 3 description thereof by its inventor, (See Proc. A.I.E.E.,  
 4 vol. 25, p. 735, 1905)/and according to the patents therefor  
 5 (U.S. patents Nos. 841,387 and 879,532) depends upon the  
 6 principle of gas ionization. The same is also true of the  
 7 Fleming detector (see the statement contained in U.S. patent  
 8 No. 954,619). In accordance with the present invention, high  
 9 voltages, without gas ionization, can be employed by exhaust-  
 10 ing the tube to a high degree, and the degree of exhaustion  
 11 necessary may be determined by the uses to which the  
 12 thermionic device is to be put. For example, where the device  
 13 is to be used as a telephone repeater or amplifier, in  
 14 which the voltages employed do not ordinarily exceed a  
 15 value of 200 volts, the degree of exhaustion need not be so  
 16 high as that required where the devices are to be employed  
 17 for furnishing energy in wireless transmission. In this  
 18 latter case, when suitable precautions are taken to denude  
 19 the walls and contents of the tube of occluded gases, it  
 20 has been found that a vacuum in which the pressure is <sup>one millionth of one millimeter</sup> ~~10<sup>-6</sup> mm~~  
 21 of mercury will suffice, such vacuum being sufficiently high  
 22 to prevent gas ionization with voltages in the neighborhood  
 23 of 600 volts and still afford a wide margin of safety. If  
 24 extreme precautions are taken for denuding the vessels and  
 25 its contents of occluded gases, much less perfect initial  
 26 vacua will suffice. In case still higher voltages are  
 27 to be employed, precaution should be taken to obtain and  
 28 maintain the vacuum so high as to make the possibility of  
 29 gas ionization negligible. Aside from the increased  
 30 difficulty and expense involved in the manufacture of such  
 31 tubes, it would, of course, be desirable to have the tubes of  
 32 this invention exhausted to the highest possible vacuum.

Para

1 In order to secure the relations required in thermionic  
2 devices of this invention, it has been found that certain  
3 methods of treatment and operation of the device are necessary,  
4 which methods will be described in connection with Fig. 3 of  
5 the drawing, which represents a form taken by a three-element  
6 thermionic repeater for telephony, and Fig. 4 which shows a  
7 form of amplifier adapted to work at higher voltages and  
8 to deliver larger amounts of power, and which, for example,  
9 has recently been used successfully in long distance radio  
10 telephony from Washington, D.C., to Honolulu, to Mare  
11 Island, California, and to Paris.

12 Referring to Fig. 3, 1 represents the filamentary  
13 cathode which may be heated by means of battery 5, 2 is a  
14 double anode, so constructed as to utilize efficiently electrons  
15 from all parts of the filament, and 3 is a glass containing  
16 vessel. The double grid structure 4 is introduced to control  
17 the current in the tube, which is set up by battery 4, in  
18 response to voltages impressed upon the grid-filament cir-  
19 cuit (input circuit) from the secondary side 7 of the  
20 transformer 7-8, whose primary 8 receives power from an  
21 incoming line. The plate-filament circuit (output circuit)  
22 contains the winding 9 of a transformer whose other winding  
23 10 is connected to the outgoing line. The object of the  
24 battery 11 is to maintain the grid at a negative potential  
25 with respect to the filament; in this condition (since  
26 only negative carriers are present) no current can flow  
27 to the grid, and the input impedance of the tube is infinite,  
28 that is, the amplifier is a voltage-operated device, consuming  
29 practically none of the energy of the input circuit. Because  
30 of this fact, it is desirable to add a resistance 12, of  
31 about half a million ohms, across the input circuit to  
32 permit efficient transfer of power with a finite transformer



1 ratio.

2 The electromotive force of the battery 4 is, in  
3 practice, about 130 volts, and it is therefore necessary  
4 as stated previously, so to prepare the tube that no appreciable  
5 gas ionization shall take place during evacuation at voltages  
6 considerably higher than this value. In this preparation  
7 the tube is evacuated, preferably with a molecular pump,  
8 using the precautions necessary in this kind of work, and  
9 impressing between anode and cathode a voltage about twice  
10 that used in normal operation. The effect of this is to  
11 subject the tube to more rigorous treatment than it will  
12 obtain in practice, and consequently to insure that gases  
13 remaining occluded in the walls and electrodes after this  
14 treatment will not be driven out during the practical opera-  
15 tion of the tube. This process of pumping and ageing the tube  
16 is carried on until no gas ionization can be detected.

17 Referring to Figs. 4 and 4-a in which parts similar  
18 to those of Fig. 3 are denoted by like numerals, 1,2,3,6  
19 denote an amplifier designed to deliver large amounts of  
20 power. In practice, several of these are connected in  
21 parallel.

22 Since these tubes are designed to operate at about  
23 600 volts, a direct current generator 4' is used instead of  
24 the battery 4 of Fig. 3; it is connected across the terminals  
25 of the larger condenser 13 which acts as a good conductor to  
26 high frequency currents in the output circuit, which latter is  
27 coupled, by means of the transformer 9-10, to the antenna.

28 A tuned circuit 7-14 is included in the input circuit,  
29 and oscillations of varying amplitude are impressed upon that  
30 tuned circuit from any suitable modulating system (not shown)  
31 connected to the terminals of coil 8.

32 According to this invention, this high power amplifier

1 is operated under those conditions in which an inappreciable  
2 number of positive gas ions is produced, namely, at or near  
3 the point B of the lower curve of Fig. 2, or the point J of  
4 the upper curve, the preliminary treatment having been such  
5 as to insure that no instability, due to ionization, shall  
6 take place except at considerably higher values of impressed  
7 voltage and power output

8       It will be understood that the operating voltage of  
9 600 volts has been given merely by way of illustration,  
10 and that it may, and undoubtedly will, be convenient to  
11 employ much higher voltages.



That I claimed is:

1. A thermionic amplifier comprising a vacuum tube, a heated electron-emitting cathode and an anode enclosed in said tube, a circuit outside of said tube connecting said anode and said cathode, and a source of direct current included in said circuit, the voltage of said source being so proportioned to the degree of the vacuum and the temperature of the cathode of said tube that the current between said cathode and anode is carried approximately exclusively by the electrons emitted by said cathode.
2. In a thermionic device, a vacuum tube, a heated electron-emitting cathode and an anode enclosed in said tube, a circuit outside of said tube connecting said cathode and anode, and a source of direct current included in said circuit, the vacuum in said tube being so high that no sudden increase in current due to gas ionization is possible except at voltages higher than that required to produce the saturation current at the operating temperature of the cathode,
3. In a thermionic device, a vacuum tube, a heated electron-emitting cathode and an anode enclosed in said tube, a circuit outside of said tube connecting said cathode and anode, and a source of direct current included in said circuit, the vacuum in said tube being so high that a working margin of safety exists between the voltage at which all electrons capable of being emitted by the filament at the temperature at which the latter is maintained flow to the plate and the voltage at which there

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White 1159307 250  
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Q 2nd Radio Eng.

Gen Elec Rev 7/19/45  
Oct 18/1913

Phys Rev 451  
after art 1402  
Langmuir

Phys Rev 22/1913  
Caldwell  
10/24/49

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is appreciable ionization of the residual gas of said tube.

2 a. The method of controlling the current in a vacuum tube having a heated cathode and a plate and a circuit including a source of direct current connecting said cathode and plate, which method consists in so proportioning the voltage of said source of current with respect to the temperature of the cathode and the degree of the vacuum in said tube, that the current varies approximately in accordance with the Child equation up to the voltage beyond which there is no appreciable increase of current with increased voltage, and in operating said tube at a voltage below that for which the current ceases to increase appreciably with increased voltage.

3 b. The method of preliminary treatment and subsequent operation of a thermionic device, which consists in subjecting it, during evacuation, to a voltage and temperature considerably higher than the normal operating voltage and temperature, in this condition evacuating said device until no ionization is produced; and subsequently operating it at the normal operating voltage and temperature.

4 a. In a thermionic reactor, a vacuum tube, a heated electron-emitting cathode, an anode and an auxiliary electrode in said tube, a circuit outside of said tube connecting said cathode and said auxiliary electrode, said circuit containing a source of electromotive force whereby the auxiliary electrode is maintained at a negative potential with respect to the cathode; a circuit connecting said cathode and anode, and a source of direct current in-

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cluded in said latter circuit, the vacuum in said tube being so high that a margin of safety exists between the voltage at which all the electrons capable of being emitted by the filament at the temperature at which the latter is maintained flow to the plate and the voltage at which there is perceptible ionization of the residual gas of said tube.

*See A  
The method  
merely  
as a  
repeater  
This structure*

7. The method of operating a thermionic device comprising a heated cathode, an anode and an auxiliary electrode, which method consists in providing in said device a vacuum so high that at the voltage employed between the cathode and the anode there is no appreciable ionization of the gas or vapor in the vacuum of said device, and impressing electric currents to be repeated on a circuit including the heated cathode and the auxiliary electrode, and establishing a circuit including the cathode and the anode, in which circuit said currents are repeated.

5. X. 2. A repeater of the thermionic type having an output circuit including a source of current so proportioned with respect to the degree of the vacuum and the temperature of the cathode of said repeater that there is no appreciable gas ionization in said repeater.

6. X. 3. In the construction of a vacuum tube amplifier of the thermionic type, the step which consists in obtaining such a vacuum that the ionization voltage for that vacuum, under the working conditions of said tube, shall be above the working voltage to be impressed upon said tube.

7. X. 4. A thermionic tube device, having its filament and the degree of its vacuum so proportioned to the

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voltage to be impressed that no appreciable gas ionization takes place.

8. ~~9.11.~~ The method of operating a vacuum tube device of the thermionic type, which consists in so relating the temperature of the filament to the vacuity and impressed voltage that no appreciable ionization takes place:

~~11.12. A vacuum tube device of the thermionic type, having the area of the filament and the degree of vacuity so related to the temperature and the impressed voltage at which the tube is to be worked that no appreciable ionization takes place when substantially all the electrons emitted are drawn to the anode.~~

9.12.13. A thermionic device wherein an electron discharge takes place between a heated cathode and an anode in a vacuum, the degree of said vacuum being so coordinated with the volume and velocity of said discharge that no gas ionization can occur during normal operation.

10.13.14. A thermionic device comprising a heated cathode and an electrode, an evacuated vessel enclosing the same, an external source of electromotive force so applied as to maintain said electrode positive with respect to said cathode, the degree of vacuum within said vessel being sufficiently high to insure that no appreciable gas ionization will be produced by said electromotive force.

11.14.15. The method of treating a thermionic device having a heated electron-emitting cathode and an anode enclosed within an evacuated vessel to insure the stable operation thereof, which method consists in applying a potential difference between said cathode and said anode during the

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process of evacuating said vessel and carrying the evacuation to a point where no gas ionization is produced at said potential difference, said potential difference being sufficiently greater than the potential difference to be employed in the normal operation of the device to insure a working margin of safety for said operation.

12. ~~12.12.16.~~ A vacuum tube comprising a heated cathode and an anode in an evacuated vessel, an external source of electromotive force connected between said anode and cathode, the temperature and area of said cathode being so proportioned to the vacuum in said vessel and to the voltage of said source that when approximately all the electrons emitted by the cathode are drawn to the anode there shall be no appreciable ionization of the residual gas in said tube.

*Insert B'*

HWE-R

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In Witness Whereof, I, \_\_\_\_\_ hereunto subscribe my

name — this

*first* day of *November* A. D., 1915

*Harold DeForest Arnold*

WITNESSES:

State of *New York*

COUNTY OF *New York*

ss:

*HAROLD DeFOREST ARNOLD*

\_\_\_\_\_ the above named petitioner \_\_\_\_\_  
being duly sworn, deposes and says that he is a \_\_\_\_\_ citizen \_\_\_\_\_  
of the United States, and resident — of — *East Orange* — in the  
County of *ESSEX* — and State of *New Jersey* —  
and that he \_\_\_\_\_ verily believes himself \_\_\_\_\_ to be the  
original, first, and sole \_\_\_\_\_ inventor of the improvement in —  
**TERNIONIC DEVICES AND METHOD OF CONSTRUCTING AND**  
**OPERATING THE SAME** \_\_\_\_\_

described and claimed in the annexed specification; that he \_\_\_\_\_ does not  
know and does not believe that the same was ever known or used before  
his \_\_\_\_\_ invention or discovery thereof; or patented or described in any  
printed publication in the United States of America or any foreign country  
before his \_\_\_\_\_ invention or discovery thereof; or more than two years prior  
to this application; or in public use or on sale in the United States for more  
than two years prior to this application and that no application for foreign  
patent has been filed by him \_\_\_\_\_ or his \_\_\_\_\_ legal representatives or  
assigns in any foreign country.

*Harold DeForest Arnold*

Sworn to and subscribed before me  
this *first* day of *November* 1915

*Charles E. Williams*

Notary Public



PAPER NO. 1  
LETTER 16

## UNITED STATES PATENT OFFICE.

In matter application

Harold D. Arnold,

Serial No. 59,210,

filed November 2, 1915.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

The attention of the Primary Examiner is respectfully directed to the similarity of subject-matter which apparently exists between this application and an application of Irving Langmuir, Serial No. 795,610, filed October 16, 1913, which is referred to in the recently issued patent to William C. White, No. 1,159,302, dated November 2, 1915.

It is respectfully requested that any allowable claims of the Langmuir application which could be made by Arnold should be suggested to him for the purposes of interference.

Applicant further wishes to call the attention of the Examiner to the specification of British patent No. 15,788 of 1914 to the British Thomson-Houston Company, Limited, and it is requested that if claims to subject-matter similar to that claimed in the said British patent have been presented by other applicants in the United States Patent Office, and found allowable, such claims should be suggested to Arnold.

Respectfully submitted,

Attorney for Harold D. Arnold.

463 West Street, New York, N.Y.

November 18, 1915.

Form 16 Rev. 1-19  
 "The Commissioner of Patents,  
 Washington, D. C.,"  
 and not any official by name.

Page No. 3  
 All communications respecting this  
 application should give the serial number,  
 date of filing, title of invention, and  
 name of the applicant.

DEPARTMENT OF THE INTERIOR  
 UNITED STATES PATENT OFFICE

WASHINGTON

APR. 18, 1916.

Mr. John C. Roberts,

463 West Street,

New York, N. Y.

U. S. PATENT OFFICE  
 APR 18 1916  
 MAILED

Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 59,240, filed Nov. 2, 1915.  
 Thermionic Devices and Method of Constructing and  
 Operating the Same.

Thomas Ewing  
 Commissioner of Patents

This application has been examined.

The letter filed Nov. 19, 1915, has been made  
 of record.

Page 4, lines 10 and 25, which battery? Line  
 26, correct the spelling of "establishing".

Page 6, line 13, which curve is meant by "upper  
 curve".

Page 10, line 20, the pressure should be definite-  
 ly specified, as "10-6 mm" is not understood.

Page 11, line 14, pluralize the last word.

The following art is made of record:

Hall, 1,114,697, Oct. 20, 1914, 179-171,  
 White, 1,159,307, Nov. 2, 1915, 250-27,  
 British patent, 15,788 of 1914, (3 sheets),  
 250-27,

Proceedings of Institute of Radio Engineers,  
 Vol. 3, No. 3, Sept. 1915. Article by  
 Langmuir at page 261, entitled "Pure Electron  
 Discharge". See Figures 4, 5 and 6,

General Electric Review, May, 1915. Article  
 on "Pure Electron Discharge", by Langmuir.  
 See Figures 3, 4, 5 and 6,

Physical Review, (New York), Vol. 2, 1913, page  
 409. Article by W. D. Coolidge entitled "A  
 Powerful Rontgen Ray Tube", See Figs. 1, 2  
 and 3,

"Conduction of Electricity Through Gases", by  
 J. J. Thomson, Cambridge University Press,  
 1908. See pages 192 and 193 and related  
 matter in Chapter VIII, especially Figure 41,



British patent, 14,892 of 1913, (1 sheet),  
250-34, Note Figures 1 to 8, inclusive,  
French patent 462,512, (1 sheet), 250-35

Claims 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14  
and 16 are rejected on each of the patents to Hull  
and White, above.

Claims 1, 2, 3, 4, 5 and 7 to 16, inclusive,  
are rejected on each of the references to British  
patent 15,788 of 1914, Proceedings of Radio Engineers  
and General Electric Review.

Claims 1, 2, 3, 4 and 9 to 14, inclusive, and 16  
are rejected on each of the references to Physical  
Review, Conduction of Electricity Through Gases,  
British patent 14,892 of 1913, and French patent,  
462,512.

It may be stated that in Hull the anode is  
member 6, the cathode member 2 and the source of  
direct current is shown at 13.

In "Conduction of Electricity through Gases"  
the examiner reads the filament AB as the cathode  
and the metal cylinder as the anode. The source  
of direct current is described but not illustrated.  
Note that at the end of article 103 the absence of  
ionization of gas is expressly mentioned.

Claim 6 is rejected on each of the references  
above cited in view of Arnold, 1,125,290, Feb. 16,  
1915, 250-27, who shows the well known idea of  
using a source of electromotive force to maintain  
the auxiliary electrode at a potential negative  
with respect to the cathode.

Claim 7 is rejected as being no method, but a  
mere recitation of the manufacture and use of the

59,310 -- 3.

article claimed in the other claims.

Claims 9, 10 and 11 are broad enough to cover any ordinary X-ray <sup>Tube</sup> when its vacuum increases to such a degree that it must be reduced to enable <sup>to</sup> it operate, as commonly occurs.

Applicant's letter calling attention to an alleged application of Languir and also to a British patent is noted and if applicant desires an interference in this case it will be necessary for him to overcome under Rule 75 or otherwise the art cited against his claims, and he is given thirty (30) days from the date of this letter within which to make such showing.

The claims are all rejected.

*Wm. A. Kinnear*  
Examiner, Division XVI.



1143



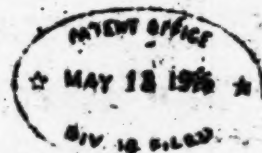
PAPER NO 4  
AMENDMENT *A*  
+ Affdt.

UNITED STATES PATENT OFFICE  
DIVISION 16 - Room 100

In re application of  
Harold D. Arnold  
Serial No. 50,310  
Filed November 2, 1915

Thermionic Devices and Method of  
Constructing and Operating the Same.

COMMISSIONER OF PATENTS,  
Washington, D. C.



Sir:

In response to the Office action of April 16, 1916,  
please amend the above entitled application as follows:

✓ Page 2, line 8, cancel "the" and insert --a--.

✓ Page 4, line 10 and line 26, after "battery" insert  
the numeral --4--.

✓ Page 8, line 13, after "curve" insert --K--.

✓ Page 10, line 20, cancel "10-6 mm." and substitute  
--one millionth of one millimeter--.

✓ Page 11, line 14, pluralize "electron".

✓ Cancel claim 7, and renumber remaining claims.

REMARKS

The Office action rejecting the claims on various  
domestic and foreign patents and on certain publications has  
been duly considered, and the applicant files herewith an  
affidavit which, under Rule 75, overcomes all references cited  
against the claims, with the exception of the Thomson publica-  
tion.

(Serial No. 59,210)

As regards the rejection of claims 1 to 4, 9 to 14 and 16 on Thomson, the following is submitted: It is not denied that the reference cited contains a clear scientific statement of the theory of electronic emission from heated metals in vacuo together with corroborating results of experiment. It is, however, emphatically denied that the reference suggests or remotely hints at the utilization of the pure electron discharge in a device useful in the art. The facts of the case are as follows: In 1903 Richardson advanced his theory of thermionic emission from heated metals in vacuo without the agency of any residual gases. This theory was not immediately accepted and indeed certain experiments, notably those of H. A. Wilson, seemed to rather discredit it, the question hinging not on the fact of emission per se, but as to whether residual gases were essential, directly or indirectly, to the liberation of electrons. It may be mentioned that it is only within the past two or three years that Richardson's theory has been established on a reasonably certain basis. In the reference cited, Thomson, in order to investigate the phenomena of thermionic emission per se did the obvious thing, namely, he eliminated the effects of gas action by as complete removal of the gases as possible. He found that the residual gas could not be completely removed with the methods of evacuation at his disposal, and, as stated in the last paragraph of the reference cited, that if the voltage was raised beyond a certain point the true phenomena of thermionic emission were masked by ionization of the residual gas. Thus the reference cited is a purely scientific statement of some of the laws governing vacuum phenomena with absolutely no suggestion of their embodiment in devices useful in the art.



(Serial No. 59,210)

The art will now be considered. In spite of the fact that Richardson's theory of thermionic or pure electronic emission was advanced in 1903 and was accepted by the majority of physicists, the whole trend of the art was to utilize the phenomena of ionization rather than pure thermionic emission. Indeed this was the obvious and straightforward course, since it was known and is known that much larger currents are obtainable in a given vacuum tube working with ionization than in the same tube when highly evacuated. To mention only a few examples of the art, the Fleming rectifier, the Von Lieben and Reich relay, the mercury arc rectifier of Hewitt and the audion of DeForest, these, as explicitly stated in the patent office disclosures of the several devices, all avowedly work on gas ionization. This is not at all surprising since, for certain uses, the presence of gas may be desirable and larger energy output made possible thereby. It remained for the applicant to discover that for certain uses, notably for the three element repeater or amplifier, the presence of gas ionization is highly deleterious and that the disadvantage due to reduction of current volume, consequent upon absence of ionization, was more than compensated for by definite advantages attaching to the pure electron discharge. He was the first to discover that the point at which ionization sets in, mentioned as a purely scientific observation by Thomson, was precisely the point at which satisfactory operation ceased. Thomson, indeed, states that under the experimental conditions he worked with, ionization sets in when the voltage was increased beyond a certain value; he does not anywhere state that the ionization point depends in a complicated way on the degree of vacuum and the temperature of the filament and nowhere hints that as ionization is highly

See Art. 103 g. Thomson

(Serial No. 89,310)

deleterious to the operation and life of the practical devices utilizing the phenomena of thermionic emission. Finally he does not anywhere even remotely hint or suggest that the point at which appreciable ionization sets in is precisely the point at which rectification in the two element device and repeater action in the three element device becomes imperfect. It is contended broadly that the mere statement of a scientific fact does not preclude subsequent invention when advantage of said scientific fact is taken to provide a practical device useful in the art. The discovery of the law of induction by Faraday carried with it the whole theory and operation of the transformer, yet it is surely not contended that the production of the transformer and the dynamo did not involve inventive thought.

Furthermore, as to claims 1, 4, 10, 11, 12 and 16, it is submitted, and again emphasized, that Thomson does not anywhere make mention of the fact that there is any relationship between the temperature of the filament and the ionization within the tube. The mere statement that the effects observed show that the electrification around an incandescent wire is a complicated phenomenon and depends, among other things, on the temperature, or that the saturation current depends on the filament temperature is not to the point. These claims are for entirely new matter so far as the reference is concerned in that they point out the importance of suitably adjusting the filament temperature to avoid ionization, and they should, it is urged, be allowed.

As to claim 9, it is submitted that, in addition to the reasons given above, Thomson is not a reference. It is admitted that Thomson performed the step of obtaining such a vacuum that the ionization voltage for that vacuum was above the working voltage impressed on his tube. But such a step

1  
1  
4  
16



(Serial No. 59,210)

has been taken in any and all discharge tubes in which ionization is not present. The applicant, however, is the first to use this step in the construction of a certain article specified in the claim; namely, a vacuum tube amplifier of the thermionic type.

As to claims 12 and 13, no mention is made by Thomson of the effect of the area of the filament or of the volume of the discharge upon the ionization.

It is thought that the above arguments regarding Thomson are such as to warrant the allowance of the claims rejected thereon. An affidavit has been filed which overcomes all other references. It appears, therefore, that this application is in condition for allowance.

Respectfully submitted,

HAROLD D. ARNOLD,

By A. C. Kanner

Attorney

463 West Street,

New York, May 11, 1916.

ENC



# 4

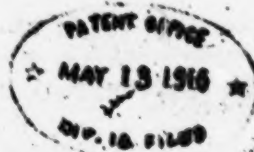
## IN THE UNITED STATES PATENT OFFICE

Harold D. Arnold

Thermionic Devices and Method of  
Constructing and Operating Same

Filed November 2, 1915

Serial No. 59,210

AFFIDAVIT OF HAROLD D. ARNOLD

State of New York )  
County of New York ) ss.

HAROLD D. ARNOLD, being duly sworn, deposes and says:

I am the applicant in the above entitled case.

The subject matter of the claims therein I conceived, described, embodied in full size operating apparatus and disclosed to others prior to December, 1915 as described in detail hereinafter, it being understood that the dates specified may not be the earliest dates of work on my invention by myself or my assistants.

The invention as embodied in the claims resulted from experimental work carried on by myself and my assistants in the laboratories of the Western Electric Company. The result of this experimental work is contained in laboratory note books, and various memoranda now in the archives of said Company. These note books and memoranda show that I first found that when the three element device, commonly called the audion, worked efficiently as a repeater or amplifier, the action was purely electronic, and that the presence of ionization was deleterious, as indicated by the poor quality of reproduction of the input voltage, as soon as gas ionization appeared. The



audion tubes which were available at and prior to the time of these first experiments were evacuated to the then customary degree, and the maximum D.C. plate voltage which could be applied without production of ionization was in the neighborhood of 40 volts, and if this voltage was exceeded, the reproduction, that is, the usefulness of the tube as a repeater, was impaired. The result of theoretical considerations taken in connection with this early experimental work, led me to believe that higher plate voltages could be used and correspondingly larger output currents obtained without ionization by using a higher vacuum. A molecular pump was therefore ordered, and immediately upon its arrival tubes were evacuated therewith to the highest possible degree. It was found that a very much higher plate voltage could then be used, that no gas ionization was present at the highest voltage tried, that the output current was much larger, and that in this case a good reproduction of the input voltage was obtained up to the maximum voltage tried. In all these tubes, however, faithful reproduction of the input voltage was obtained so long as the voltage, filament temperature and vacuity were so related as to avoid the presence of any ionized gas in the tube. This experimental work was carried on, the memoranda and note book records were made, and the invention was reduced to practice prior to December, 1913, and the said invention is now in public use.

The subject-matter of the claims herein was not in public use or on sale in this country for more than two years prior to the date of said application so far as my present knowledge or information extends, and has never been abandoned by me.

*Frank B. Rowland*

Subscribed and sworn to  
before me this 5<sup>th</sup>  
day of May, 1916.

New York, N. Y.

ENC 215 Cs

NOTARY PUBLIC  
NEW YORK COUNTY, NY 237  
NEW YORK REGISTRY NO. 215

Div 16 Rev. 109

Paper No. 5

Copy sent to  
assignee  
and ap-  
plicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

June 15, 1916.

Mr. John G. Roberts.

465 West Street.

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 59,810, filed Nov. 21, 1915,  
Thermionic Devices and Method of Constructing and  
Operating the Same.

*Thomas Ewing*  
Commissioner of Patents

This action is in response to amendment filed  
May 12, 1916.

The following claims are suggested to appli-  
cant for purposes of interference. Applicant is  
given twenty days from date of this letter within  
which to present them. Failure to present such  
claims within the time stated will be held an  
abandonment of their subject-matter.

An electrical discharge device comprising a  
gas-tight envelope, an incandescent cathode, and  
a gas-free anode, the space in said envelope being  
evacuated to below the pressure at which deleterious  
gas ionization takes place, the current passed by  
said device over a working range of voltage and tem-  
perature varying with the  $3/2$  power of the impressed  
voltage for voltages above a minimum voltage depend-  
ing on the temperature of the cathode.

A high vacuum electron discharge device com-  
prising an envelope, an incandescent cathode, and an  
anode, the space in said envelope being evacuated to  
such degree that the passage of current produces no  
appreciable positive ionization when the impressed  
voltage is as high as 800 volts.

An electrical discharge device comprising a  
gas-tight evacuated envelope, a cathode adapted to  
be heated to incandescence, an anode, the space in  
said envelope being evacuated to such a degree that  
the current flowing between said electrodes varies  
with the  $3/2$  power of the impressed voltage over a  
working range of current values exceeding about five  
milliamperes



59,810 -- 2.

An electrical discharge device comprising a gas-tight envelope, an incandescent cathode, an anode, and means for independently heating the cathode, the parts of said apparatus and the enclosed space being deprived of gas to such extent that the device is operable with currents varying with the  $3/8$  power of the voltage over a range of impressed voltages determined by the cathode temperature, the current at voltages above this range being substantially constant.

*Spencer Kinnear*  
Examiner, Division XVI.

PAPER No. 6  
AMENDMENT BUNITED STATES PATENT OFFICE  
Division 16 - Room 109

In re application of

Harold D. Arnold

Serial No. 89,210

Filed November 2, 1915

Thermionic Devices and Method of  
Constructing and Operating the Same.COMMISSIONER OF PATENTS,  
Washington, D. C.PATENT OFFICE  
JUN 29 1916  
DIV 16 FILED

Sir:

Please amend the above entitled application by adding  
the following four claims as claims 16 to 19 inclusive:

--16. An electrical discharge device comprising a gas-tight envelope, an incandescent cathode, and a gas-free anode, the space in said envelope being evacuated to below the pressure at which deleterious gas ionization takes place, the current passed by said device over a working range of voltage and temperature varying with the  $3/2$  power of the impressed voltage for voltages above a minimum voltage depending on the temperature of the cathode.

13-14. A high vacuum electron discharge device comprising an envelope, an incandescent cathode, and an anode, the space in said envelope being evacuated to such degree that the passage of current produces no appreciable positive ionization when the impressed voltage is as high as 200 volts.



(Serial No. 59,210)

18. An electrical discharge device comprising a gas-tight evacuated envelope, a cathode adapted to be heated to incandescence, an anode, the space in said envelope being evacuated to such a degree that the current flowing between said electrodes varies with the  $3/2$  power of the impressed voltage over a working range of current values exceeding about five milliamperes.

19. An electrical discharge device comprising a gas-tight envelope, an incandescent cathode, an anode, and means for independently heating the cathode, the parts of said apparatus and the enclosed space being deprived of gas to such extent that the device is operable with currents varying with the  $3/2$  power of the voltage over a range of impressed voltages determined by the cathode temperature, the current at voltages above this range being substantially constant.--

## REMARKS

The above claims are those suggested to applicant for the purpose of interference in Office action of June 15, 1916.

Respectfully,

HAROLD D. ARNOLD

Attorney.

443 West Street,

New York.

June 27, 1916.

643-68

643

## INTERFERENCE.

Interference No. 40380

Paper No. 7

Name, Harold R. S. Arnold

Serial No. 59 210

Title, Harmonic Device and Method of Con-  
struction and Operating the Same

Filed, Nov 2, 1915

Interference with J. Sangster

## DECISIONS OF

Law  
Primary Examiner, J. H. Dyer, dated, Feb 25, 1921

Ex'r of Interferences,

Adverse

Dated, Oct 21/21

Board,

Dated, April 21/23

Commissioner,

Favorable

Dated, OCT 27 1923

Court,

Adverse

Dated Jan 1, 1925

## REMARKS:

Termination of Oath noted by P. E.  
July 11, 1925



July 31, 1916.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C.

P. H.

Copy sent assignee.

Mr. John G. Roberts,

463 West Street,

New York, N. Y.

U. S. PATENT OFFICE,  
INTERFERENCE DIVISION  
AUG 8 - 1916  
MAILED

Please find below a copy of a communication from the Examiner concerning the application of Harold DeF. Arnold, S. No. 59,210, filed Nov. 2, 1915, Thermionic Devices and Method of Constructing and Operating the Same.

Room No. 309

Very respectfully,

ADDRESS ONLY  
THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.

1-104

Thomas Edison  
Commissioner of Patents.

40380

The case, above referred to, is adjudged to interfere with others, hereafter specified, and the question of priority will be determined in conformity with the Rules.

The statement demanded by Rule 110 must be copied up and filed on or before

SEP 5 - 1916

with the subject of the invention, and name of party filing it, indorsed on the envelope. The subject-matter involved in the interference is:

1. In a thermionic device, a vacuum tube, a heated electron-emitting cathode and an anode enclosed in said tube, a circuit outside of said tube connecting said cathode and anode, and a source of direct current included in said circuit, the vacuum in said tube being so high that no sudden increase in current due to gas ionization is possible except at voltages higher than that required to produce the saturation current at the operating temperature of the cathode.

2. In a thermionic device, a vacuum tube, a heated electron-emitting cathode and an anode enclosed in said tube, a circuit outside of said tube connecting said cathode and anode, and a source of direct current included in said circuit, the vacuum in said tube being so high that a working margin of safety exists between the voltage at which all electrons capable of being emitted by the filament at the temperature at which the latter is maintained flow to the plate and the voltage at which there is appreciable ionization of the residual gas of said tube.

3. A vacuum tube device of the thermionic type, having the area of the filament and the degree of vacuity so related to the temperature and the impressed voltage at which the tube is to

59,310 -- 3.

be worked that no appreciable ionization takes place when substantially all the electrons emitted are drawn to the anode.

4. An electrical discharge device comprising a gas-tight envelope, an incandescent cathode, and a gas-free anode, the space in said envelope being evacuated to below the pressure at which deleterious gas ionization takes place, the current passed by said device over a working range of voltage and temperature varying with the  $3/2$  power of the impressed voltage for voltages above a minimum voltage depending on the temperature of the cathode.

5. A high vacuum electron discharge device comprising an envelope, an incandescent cathode, and an anode, the space in said envelope being evacuated to such degree that the passage of current produces no appreciable positive ionization when the impressed voltage is as high as 300 volts.

6. An electrical discharge device comprising a gas-tight evacuated envelope, a cathode adapted to be heated to incandescence, an anode, the space in said envelope being evacuated to such a degree that the current flowing between said electrodes varies with the  $3/2$  power of the impressed voltage over a working range of current values exceeding about five milliamperes.

7. An electrical discharge device comprising a gas-tight envelope, an incandescent cathode, an anode, and means for independently heating the cathode, the parts of said apparatus and the enclosed space being deprived of gas to such extent that the device is operable with currents varying with the  $3/2$  power of the voltage over a range of impressed voltages determined by the cathode temperature, the current at voltages above this range being substantially constant.

The interference involves your application above identified and

An application for Electrical Discharge Apparatus and the Process of Preparing the Same, filed by Irving Langmuir, C/o General Electric Co., Schenectady, N. Y., whose attorney is Albert G. Davis, C/o General Electric Co., Schenectady, N. Y., and whose assignee is the General Electric Co., Schenectady, N. Y.

The relation of the counts of the interference



1157

59,210 N. 3.

to the claims of the respective parties is as follows:

Counts:	Arnold:	Langmuir:
1	2	20
2	3	21
3	11	22
4	16	4
5	17	5
6	18	9
17	19	16

*Wm. A. Kinnear*  
Examiner, Division XVI.

*Caper No. 14*  
*Amenat. C.*

## UNITED STATES PATENT OFFICE.

Division 16.

Room 109.

Harold D. Arnold

Serial No. 59210

Filed November 2, 1915

Invention: Thermionic Devices and  
 Method of Constructing  
 and Operating the Same.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

By the present letter, amendments are made in response to the suggestion contained in the last paragraph of the inter partes decision by the Law Examiner on February 25, 1921, and this occasion is taken to make certain further amendments, believed to be appropriate at this time, ~~and~~ for which the applicant now respectfully asks leave.

✓ Page 7, line 3, change "rises" to -- may rise --; line 9, after "space" insert -- and occluded in the electrodes, inner tube walls, etc. --; line 24, after "present" insert --, as by liberation from the electrodes or tube walls by the energy dissipated in the tube --; line 27, after "present" insert -- or are readily liberated in the tube --.

✓ Page 8, line 1, after "distortion", insert -- In this case the abscissa of the diagram, Figure 2, may not represent the mere plate potential, but it may combine the plate and grid potentials in the proper proportion. --; line 15,

change "somewhat better" to -- tube somewhat better prepared to hold its --.



Add the following claims:

✓ 14. An electrical device comprising the combination of a sealed evacuated envelope, a cathode adapted to be independently heated, and an anode within said envelope, an external circuit connected to said electrodes, and a source of electro-motive force applied to said circuit, the degree of vacuity and the electron emission of the cathode being so related to the potential of said source that the flow of current over a range of voltage materially above the ionization voltage is governed by the electric field of the electrons in the vacuum space and the potential applied to said electrodes, operatively independent of gas ionization.

15. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the governing or limiting action on the space current due to the electric field of said electrons is substantially unaffected by positive ionization and by secondary electron emission from the walls of the tube.

16. A discharge tube having a cathode adapted to emit electrons and an anode adapted to receive said emitted electrons, the tube walls being fashioned or shaped to permit direct passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the electric field of said electrons substantially unaffected by positive ionization.

17-23. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that in that range the space current is governed by the combined effect of the electric field of said electrodes and the potentials applied to said electrodes, the governing or limiting of the current being substantially unaffected by positive ionization and by secondary electron emission from the walls of the tube.

18-24. A discharge device comprising a tube and electrodes therein one of which is adapted to emit electrons, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed upon electrodes of the device and when the electron emission has any values such that the space current is below the saturation region at such voltages, that the slope of the line obtained by plotting the logarithms of values of said current as ordinates against the logarithms of the corresponding values of said impressed voltages as abscissas shows no increase for increasing voltage values.

19-25. A discharge device comprising a tube and electrodes therein one of which is adapted to emit electrons, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the device and when the electron emission has any value such that the space current is below the saturation region at such voltages, that



the line obtained by plotting the logarithms of any values of said current below the saturation region as ordinates against the logarithms of the corresponding values of said impressed voltages as abscissae is straight and continuous.

20-34. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated when voltages materially higher than ionization voltages are impressed on electrodes of the tube and when the electron emission has any value such that the space current is below the saturation region at such voltages, that said current varies as the three halves power of said impressed voltages.

21-37. A discharge device comprising a tube and electrodes therein one of which is an electron emitting cathode, the degree of evacuation of said device and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the device and when the electron emission is such that the space current is below the saturation region at such voltages, that said current is substantially independent of the cathode temperature and unaffected by secondary electron emission from the walls of the tube.

22-38. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the combined effect of the electric field of said electrons

and the potentials applied to said electrodes, substantially unaffected by positive ionization, the heating effect in the tube due to said current occurring substantially only at one or more of said electrodes.

23 39. A discharge tube having a cathode adapted to emit electrons, an anode adapted to receive electrons and tube walls fashioned or shaped so as to permit the free passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of operation with stable and reproducible results substantially unaffected by positive ionization with currents of at least five milliamperes and with voltages of at least 200 volts.

24 39. Apparatus for controlling an electric current comprising a vacuum tube, an anode and an electron emitting cathode in the circuit of said current and within said tube, the degree of evacuation of the tube and the relation of its parts being such that for voltages materially above ionization voltage the current is governed or limited by the electric field of the electrons in said tube substantially unaffected by positive ionization, and a third electrode in said tube by which an auxiliary controlling electro-motive force may be superposed to modify the effect of said electric field and control said current in a stable and reproducible manner.

25 39. The method of controlling an electric current in one circuit by an electro-motive force in another circuit *at voltages materially above ionization voltages* which consists in causing said current to pass as a discharge across a vacuum space between an electron emitting cathode and an anode, maintaining a high vacuum in said space, governing or limiting the current by a space charge effect



*substantially unaffected by positive ionization*  
 in said space, and superimposing the effect of said electro-  
 motive force on said space charge effect to control said cur-  
 rent in a stable and reproducible manner, ~~substantially un-~~  
~~affected by positive ionization.~~

*Inserted*

#### REMARKS

The amendments to the specification preceding the claims amount to a repetition, at one page of the specification, of statements that appear explicitly elsewhere. It is thought that such repetition will serve to dispel any possible lack of clearness at the points where the amendments are introduced. In this connection, reference is made to the original specification, page 8, lines 15 and 16; page 8, line 7; page 10, line 25; and page 12, line 14, which refer to the same matter.

The new claims submitted by this amendment and numbered 20 to 29 inclusive, correspond respectively to the opposing party's claims 26 and 1 to 9 inclusive, and are made in direct response to the suggestion of the Patent Office.

The high vacuum and the space charge effect to which the foregoing claims refer are of peculiar significance in connection with a tube having a third electrode, for by virtue of the space charge effect it becomes possible definitely to influence the space current by a mere slight change of potential on the third electrode, and the absence of positive ionization insures stable and reproducible operation. One of the useful functions of a tube thus characterized is that it becomes possible to put a considerable negative potential on the third electrode without producing any considerable current in the circuit of that third electrode. Following the Law Examiner's decision, it is believed that these aspects of the pure

electron discharge tube should be stated in claims and patented. Accordingly claims 30 and 31 have been drawn along lines indicated in the decision of the Law Examiner, which decision has now become part of the "law of the case". In connection with these new claims, attention is directed to applicant's original claims 4 and 6 inter alia.

Favorable action at an early date is requested.,

Respectfully submitted,

By HAROLD D. ARNOLD,

Per

George E. Falk  
Attorney.



Address only  
The Commissioner of Patents  
Washington, D. C.  
and is not to be used for other purposes.

This communication must give the name of the applicant, the title of the invention, and the name of the inventor.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Mr. John C. Roberts,

463 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of  
Harold D. Arnold, Ser. #59,210, filed Nov. 2, 1915.

Thermionic Devices and Method of Constructing and Operating same.

M. H. COULSTON

Assistant to the Commissioner of Patents

The following counts have been added to interference

No. 40,380, ARNOLD vs. LANEMUIR, in accordance with the decisions  
of the Law Examiner dated Feb. 25, 1921 and March 18, 1921:

2. An electrical device comprising the combination of a sealed evacuated envelope, a cathode adapted to be independently heated, and an anode within said envelope, an external circuit connected to said electrodes, and a source of electromotive force applied to said circuit, the degree of vacuity and the electron emission of the cathode being so related to the potential of said source that the flow of current over a range of voltage materially above the ionization voltage is governed by the electric field of the electrons in the vacuum space and the potential applied to said electrodes, operatively independent of gas ionization.

3. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the governing or limiting action on the space current due to the electric field of said electrons is substantially unaffected by positive ionization and by secondary electron emission from the walls of the tube.

4. A discharge tube having a cathode adapted to emit electrons and an anode adapted to receive said emitted electrons, the tube walls being fashioned or shaped to permit the direct passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the electric field of said electrons substantially unaffected by positive ionization.

5. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that in that range the space current is governed by the combined effect of the electric field of said electrons and the potentials applied to said electrodes, the governing or limiting of the current being substantially unaffected by positive ionization and by secondary electron emission from the walls of the tube.

6. A discharge device comprising a tube and electrodes therein one of which is adapted to emit electrons, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed upon electrodes of the device and when the electron emission has any value such that the space current is below the saturation region at such voltages, that the slope of the line obtained by plotting the logarithms of values of said current, as ordinates against the logarithms of the corresponding values of said impressed voltages as abscissae shows no increase for increasing voltage values.

7. A discharge device comprising a tube and electrodes therein one of which is adapted to emit electrons, the degree of evacuation and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the device and when the electron emission has any value such that the space current is below the saturation region at such voltages, that the line obtained by plotting the logarithms of any values of said current below the saturation region as ordinates against the logarithms of the corresponding values of said impressed voltages as abscissae is straight and continuous.

8. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the tube and when the electron emission has any value such that the space current is below the saturation region at such voltages, that said current varies as the three halves power of said impressed voltages.

9. A discharge device comprising a tube and electrodes therein one of which is an electron emitting cathode, the degree of evacuation of said device and the relation of the parts of the device being such that the device is capable of being so operated, when voltages materially higher than ionization voltages are impressed on electrodes of the device and when the electron emission is such that the space current is below the saturation region at such voltages, that said current is substantially independent of the cathode temperature and unaffected by secondary electron emission from the walls of the tube.



10. A discharge tube having electrodes at least one of which is adapted to emit electrons, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionisation voltages that the space current is governed or limited by the combined effect of the electric field of said electrons and the potentials applied to said electrodes, substantially unaffected by positive ionisation, the heating effect in the tube due to said current occurring substantially only at one or more of said electrodes.

11. A discharge tube having a cathode adapted to emit electrons, an anode adapted to receive electrons and tube walls fashioned or shaped so as to permit the free passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of operation with stable and reproducible results substantially unaffected by positive ionisation, with currents of at least 5 milliamperes and with voltages of at least 200 volts.

12. Apparatus for controlling an electric current comprising a vacuum tube, an anode and an electron emitting cathode in the circuit of said current and within said tube, the degree of evacuation of the tube and the relation of its parts being such that for voltages materially above ionisation voltage the current is governed or limited by the electric field of the electrons in said tube substantially unaffected by positive ionisation, and a third electrode in said tube by which an auxiliary controlling electromotive force may be superposed to modify the effect of said electric field and control said current in a stable and reproducible manner.

13. The method of controlling an electric current in one circuit by an electromotive force in another circuit which consists in causing said current at voltages materially above ionisation voltages to pass as a discharge across a vacuum space between an electron emitting cathode and an anode, maintaining a high vacuum in said space, governing or limiting the current by a space charge effect in said space substantially unaffected by positive ionisation, and superimposing the effect of said electromotive force on said space charge effect to control said current in a stable and reproducible manner.

The preliminary statement required by Rule 110, as to the added counts only, should be filed on or before **MAY 2 1921**

The relation of all the counts to the claims of the parties is now as follows:

COUNTS:   ARNOLD:   LANE:

1	19	14
2	20	25
3	21	1
4	22	2
5	23	3
6	24	4
7	25	5
8	26	6

Ser. #59,210 - #4.

Counts: Arnold: Langmuir: (con):

9	27	7
10	28	8
11	29	9
12	30	38
13	31	39

In applicant's claim 28, line 3, the should be inserted after "permit" to agree with count 4 as declared.

H. H. M.

*C. D. Backus*

Exr., Div. 16.

66/49



1169

Div. 51

Room 240-ANNEK

2-000

Page No. 18

Address only  
The Commissioner of Patents,  
Washington, D. C.  
and not any official by name

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON

Sept. 14, 1925.

Please find below a communication from the EXAMINER in charge of this application

*James E. Robertson*  
Commissioner of Patents

Applicant, H. D.F. Arnold

John G. Roberts,

464 West Street,

New York, N.Y.

Ser. No. 59,210

Filed Nov. 2, 1915

For Thermionic Devices and  
Method of Constructing and  
Operating the Same.

MAILED

SEP 16 1925

This application comes before the examiner on the termination of the interference in which it was involved.

Claims 27 and 30-31 stand finally rejected in view of the adverse decision in the interference.

Claims 2, 3, 11, 16, 18 and 19 stand finally rejected in view of the last Examiner's decision in the interference.

Claims 1, 4-10 and 12-15 are rejected on the adverse decision in the interference.

In view of the long pendency of this case applicant's next movement should place the case in condition for final adjudication.

RAM

*C. O. Lawrence*

Examiner, Div. 51.

66/50

1170

PAPER NO. 19  
AMENDMENT 2

MAY 1915  
U.S. PATENT OFFICE

UNITED STATES PATENT OFFICE.

Division 51

Room 240-Annex

HEROLD P. ANNOLD

Serial No. 59,510

Filed November 2, 1915

Invention: Thermionic Devices and Method of Constructing and Operating the Same.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

PATENT OFFICE  
MAY 3 - 1925  
DIV. OF PATS.

In response to the Office action dated September 14, 1925, amendment is made as follows:

- ✓ Cancel Claims 2, 3, 11, 16, 18 and 19.
- ✓ Renumber the remaining claims as 1 to 25.
- ✓ Add the following claims:

--25. The method of amplifying a variable electric current without distortion, which comprises producing a substantially pure electron discharge from a hot cathode across said cathode and anode at a voltage for which the variation of the current with the voltage is most nearly constant, and applying the input current to produce corresponding electromotive forces across said cathode and a grid, thereby varying said discharge within the range for which the ratio of current increment to voltage increment remains substantially constant.

--27. The method of amplifying a variable electric current without distortion, which comprises producing a substantially pure electron discharge from a hot cathode across said cathode and anode at a voltage corresponding to a point on the volt-ampere characteristic just below its knee, and applying the input

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E



current to produce electromotive forces across said cathode and a grid, thereby varying said discharge within a voltage range corresponding to a part of said characteristic that exhibits no substantial departure from a straight line.

--25. The method of amplifying a variable electric current without distortion, which comprises the production of a substantially pure electron discharge from a hot *As an anode across said cathode and anode* cathode at a voltage for which the corresponding current shows only the beginning of the saturation effect, and applying the input current to produce electromotive forces across said cathode and a grid to vary said discharge within a comparatively narrow voltage range.--

#### REMARKS.

Favorable reconsideration for this application as now presented is respectfully requested.

Applicant has cancelled the claims rejected by the Examiner on the authority of the Law Examiner's decision.

Applicant notes the rejection of the remaining claims 1 to 25 as now renumbered, and recognizes that the Examiner, at this time is necessarily governed by the decision of the Court of Appeals of the District of Columbia to which he refers. These claims are retained to preserve applicant's rights under Section 4915 of the Revised Statutes.

The new claims 26, 27 and 28 added by the present amendment are directed to advantageous utilization of a three electrode vacuum tube as an amplifier. The principle involved is to work in that part of the voltage range substantially above the voltages at which gas ionisation ordinarily occurs (page 6 of specification.

line 23 and context) and below voltages approaching saturation, where the ratio between output current increments and input voltage increments is substantially constant. This is explained in the specification, page 7 line 29 et seq.

Said Claims 26, 27 and 28 could not have been made in the application with which the present application was in interference and they are believed to be directed to novel, patentable subject-matter.

Applicant hereby notifies the Patent Office that on April 29, 1926 he and his assignee filed a suit under Section 4915 of the Revised Statutes against the opposing parties in interest in the Interference heretofore mentioned. It is understood that under the doctrine of *Candy v. Marble*, 122 U. S. 432 and other cases, the prosecution of said suit will be regarded as a continuation of prosecution of the present application, and that the Patent Office will hold the present application not subject to abandonment by operation of the statute and rules of practice while the said suit is being prosecuted.

Subject to the conditions stated in the foregoing remarks, favorable action at an early date is requested.

Respectfully submitted,

By HAROLD D. ARNOLD,

Per

g. w. h.  
Attorney.

New York, April 30, 1926.

Go on with the  
rest of the case



1173

No. 51

Serial 240-1222

Page No. 20

The Commissioner of Patents  
and the Secretary of Commerce  
are authorized to receive and  
transmit applications for  
patents and to receive and  
transmit communications from  
the Patent Office.

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

Washington May 20, 1926.

Please find below a communication from the EXAMINER in  
charge of this application

*Thomas E. Chilton*  
Commissioner of Patents

Applicant: E. De F. Arnold

John G. Roberts,  
465 West Street,  
New York, N.Y.

Ser. No. 93210  
Filed Nov. 1, 1925  
For X-RAY DEVICE AND  
METHOD OF CONSTRUCTING AND  
OPERATING THE SAME.

MAY 20 1926

Responsive to amendment filed May 1, 1926.

Claims 26, 27 and 28 are rejected as improper ~~effect~~  
claims since they contain apparatus limitations. These claims  
are not expressed independently of the specific structure of  
the articles employed or independently of the structure of  
the apparatus through which the process is carried out.

Claims 26 to 28 are further rejected as indefinite  
in that they fail to clearly indicate whether the voltage  
recited is to be interpreted as the filament or plate source  
of energy.

*awc*

*W. D. Shaw*  
Assistant Commissioner

1174

No. 31

Room 240-Annex

Paper No. 22

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON June 7, 1926.

AUG/tr

Please find below a communication from the EXAMINER in charge of this application

*Thomas E. Robertson*  
Chief Examiner of Patents

Applicant: H. De P. Arnold

John G. Roberts,  
463 West Street,  
New York, N.Y.

Ser. No. 59210  
Filed Nov. 2, 1915  
For THERMIONIC DEVICES AND  
METHOD OF CONSTRUCTING AND  
OPERATING THE SAME.

JUN 7 1926

Responsive to letter filed June 1, 1926.

A certified copy of the Bill of Complaint has been entered in this case. Applicant is advised however, that this does not alter the status of the case as regards the rejection of claims 1-25 or the rejection of claims 26 to 28.

Applicant may retain claims 1 to 25 in the case to preserve his rights under Section 4915 of the Revised Statutes.

A response to the rejection of claims 26 to 28 must be filed on or before May 20, 1927.

*awc*

*[Signature]*  
Examiner.



1175

PAPER No 23  
AMENDMENT E

MAIL ROOM  
MAY 8 1927  
PATENT OFFICE

UNITED STATES PATENT OFFICE

Division 51

Room 240-Annex

E  
Harold D. Arnold :  
Serial No. 59,210 : Invention: Thermionic Devices and  
Filed November 2, 1915: Method of Constructing and  
Operating the Same.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

In response to the Office Letters dated May 20,  
1926 and June 7, 1926, amendment is made as follows:

Claim 26, line 3, after "cathode" insert --to  
an anode--; same claim, line 4, after "voltage" insert  
--across said cathode and anode--; same claim, last line,  
after "increment" insert --across said cathode and anode--.

Claim 27, line 3, after "cathode" insert --to  
an anode--; same claim, line 4, after "voltage" insert  
--across said cathode and anode--.

Claim 28, line 4, after "cathode" insert --to an  
anode--; same line, after "voltage" insert --across said  
cathode and anode--.

REMARKS

Favorable reconsideration for this application  
now presented is respectfully requested.

Applicant notes the statement by the Office  
that a certified copy of the Bill of Complaint in this  
case under R. S. Section 4915 has been entered and made  
of record. The case referred to has not yet come to

PATENT OFFICE  
MAY 6 - 1927  
DIV. 51-123

trial; whenever there is any significant development in it, the applicant will notify the Patent Office.

In regard to the rejection of claim 24, this is understood to be based on two grounds.

One of these grounds is that these claims are "improper method claims since they contain apparatus limitations". Most patentable methods can be performed only with the aid of apparatus elements, and most such methods can be claimed only with mention of the apparatus elements involved. Even if a studied wording is employed that evades the mention of the apparatus elements, nevertheless they are implied and understood, and since the Patent Office will look to substance rather than form, it will not discriminate against method claims merely because they make explicit mention of apparatus elements that are implied and understood whether they are mentioned or not.

The most undoubted method claims, such as those relating to chemical methods, necessarily involve apparatus elements, whether expressed or not. If a solution is to be filtered, a filter is involved; if a precipitate is to be roasted, a burner or an oven or something of the sort is involved; etc. The foregoing argument is not altered by the fact that in comparatively rare exceptional cases there are patentable methods that are performed without apparatus, as, for example, some methods of weaving by the unaided fingers.

Consider claim 24. The first apparatus element mentioned is the "hot cathode". In form this could be avoided by applying the adjective "thermionic" to the noun "discharge" in the same line of the claim. But this would be a mere change of form, for a thermionic



discharge necessarily implies a hot cathode. It is believed that the Office will not insist on such changes of form which do not really affect the substance.

Again, in the same claim, mention is made in line 7 of "a grid". Perhaps this could be avoided by calling for the production of an electric field upon and about said cathode. But everyone knows that such a superposed electric field could only be produced by the aid of an electrode between which and the cathode the lines of electric force would extend. Applicant respectfully submits that it would be better bluntly to say "a grid" instead of adopting a circumlocution that implies the same thing but avoids expressly saying it.

To summarize on this phase of the case, it is respectfully submitted that claim 26, and likewise claims 27 and 28, are true method claims. They do not present a necessary function of the apparatus elements mentioned therein. Those elements could be used in diverse ways, and the use of them presented in these claims is a true patentable method.

In the interference in which this application has been involved method claims have been allowed which mention apparatus elements. For example, consider claim 22 of the Langmuir patent 1,580,436. This claim has been regarded as a true method claim although it mentions "a discharge" between an electron emitting cathode and an anode.

In regard to the second ground of rejection against the claims, namely, that they fail to clearly indicate whether the voltage recited is to be interpreted as the filament or plate source of energy, this

has been met by what is believed to be an appropriate amendment in each claim. Stated briefly and informally, the method of these claims involves, first, setting up a pure electron thermionic discharge with a locally adjusted voltage across the hot cathode and the corresponding anode; then, having secured the right adjustment of this voltage, as pointed out in the claims, the electromotive forces corresponding to the currents to be amplified are superposed in their effect on the cathode, and thereby amplified variations in the main discharge current are produced. It is believed that the amendments make this entirely clear.

Favorable action at an early date is requested.

Respectfully submitted,

HAROLD D. ARNOLD,

By

J. B. Roberts  
Attorney.

MAY - 4 1927



1179

Div. 51  
Address only  
The Commissioner of Patents  
Washington, D. C.  
and not any other office

Room

240

INDEX

AMU:H

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON

May 18, 1927.

Page No. 24

All communications respecting this  
application should give the serial number  
date of filing and inventor's name  
as indicated on the official

Please find below a communication from the EXAMINER in  
charge of this application.

*Thomas E. Robertson*  
Commissioner of Patents

Applicant: H. De Forest Arnold

John G. Roberts,  
463 West St.,  
New York City, N. Y.

Ser. No. 59,210

Filed Nov. 2, 1915

For Thermionic Devices and  
Method of Constructing and Operating  
the Same.

MAILED

In response to amendment of May 5, 1927.

MAY 18 1927

Claims 26 to 28 are again rejected as improper  
method claims for reasons stated in the Office Action of  
May 20, 1926.

If applicant is of the opinion that these claims  
can be amended to avoid the objections of record by merely  
changing their form, he is advised to take such an action.  
the proceedings under

In view of Section 4915 R. S. no further action on  
claims 1 to 25 is taken at this time.

*AWC*

*Q. D. Bacon*  
Examiner.

THIS ACTION MUST BE RESPONDED TO WITHIN SIX MONTHS.

1180

PAPER NO. 25  
AMENDMENT

## UNITED STATES PATENT OFFICE

Division 51

Room 240-Annex

Harold D. Arnold

Serial No., 59,810

Filed November 2, 1925

Invention: Thermionic Devices and  
Method of Constructing and  
Operating the Same.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

In response to the Office action dated May 18,  
1927, amendment is made as follows:

✓ Add the following claims:

--29. The method of amplifying a variable electric current without distortion which comprises producing a substantially pure electron discharge current at a corresponding adjusted voltage for which the variation of the current with the voltage is most nearly constant, and applying the said variable electric current to produce corresponding superposed electro-motive forces in the path of said discharge current, and thereby varying said discharge current accordingly within the range for which the ratio of current increment to voltage increment for said discharge current remains substantially constant.

--30. The method of amplifying a variable electric current without distortion which comprises producing a substantially pure electron discharge current at a corresponding adjusted voltage on the current-voltage characteristic just



below its knee, and applying the said variable electric current to produce corresponding superposed electro-motive forces in the path of said discharge current, and thereby varying said discharge current accordingly within a range corresponding to a part of said characteristic that manifests no substantial departure from a straight line.

--31. The method of amplifying a variable electric current without distortion which comprises the production of a substantially pure electron discharge current at a corresponding adjusted voltage for which the said discharge current shows only the beginning of the saturation effect, and applying the said variable electric current to produce electro-motive forces in the path of said discharge current to vary it within a comparatively narrow voltage range.

--32. The method of amplifying a variable electric current without distortion which comprises producing a substantially pure electron discharge current, limited by a space charge effect and at a corresponding adjusted voltage for which the variation of the current with the voltage is most nearly constant, and applying the said variable electric current to produce corresponding electro-motive forces superposed on said space charge effect, and thereby varying said discharge current accordingly within the range for which the ratio of current increment to corresponding voltage increment for said discharge current remains substantially constant.

#### REMARKS.

Favorable consideration for this application as now presented is respectfully requested.

As to the rejection of Claims 26 to 28, this is understood to be on the ground that "they contain apparatus limitations", quoting from the Examiner's letter of May 20, 1926. For the reasons stated in the letter filed May 5, 1927, it is respectfully urged that there is not enough mention of apparatus in these claims to warrant their rejection.

Of the new claims now presented by amendment, those numbered 29, 30 and 31 have been patterned respectively after Claims 26, 27 and 28 but with care to avoid explicit mention of elements of apparatus. Whether or not the Examiner's criticism of Claims 26, 27 and 28 is just, it is respectfully submitted that new claims avoid such criticism and should be allowed accordingly.

The new claim added by this amendment, numbered 32, is somewhat along the line of Claims 26 and 29 but differs from these in its mention of the space charge effect. In that aspect of the invention which is involved in Claim 32, the electron discharge is at such a corresponding voltage adjustment that it is limited in value by the space charge effect; and on this is superposed the effect of the variable current which is to be amplified.

In regard to the "proceedings under Section 4915 R.S.", which have been mentioned heretofore, the case in the Southern District of New York is on the calendar awaiting call for trial.

Favorable action at an early date is requested.

Respectfully submitted,

HAROLD D. ARNOLD,

By

*John S. Edwards*  
Attorney.

NOV 14 1927



1183

Div. 51 Room 240-Annex

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Washington, D.C.  
and not by mail by name

AWC/cr

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON July 2, 1928.

Page No. 26

Examination of the application  
has been made and the  
same is hereby approved  
and the patent is granted

Please find below a communication from the EXAMINER in  
charge of this application.

*James E. Chilton*  
Commissioner of Patents

Applicant: H. De Forest Arnold

John G. Roberts,  
453 West Street,  
New York, N.Y.

Ser. No. 59210  
Filed Nov. 2, 1916  
For THERMIONIC DEVICES AND  
METHODS OF CONSTRUCTING AND  
OPERATING THE SAME.

JUL 2 1928

Responsive to amendment filed Nov. 15, 1927.

It appears from the testimony presented in  
General Electric Co., vs. DeForest Radio Co., decided in the  
District Court of the United States for the district of  
Delaware by Judge Hugh M. Morris, that a prima facie case of  
public use exists against this applicant. This conclusion  
is based on the further fact that the amplifying characteristic  
of three electrode tube was already known. Public use of an  
amplifier by De Forest in 1912 was apparently accompanied by no  
great degree of secrecy; claims 26-32 are accordingly rejected.

In view of the proceedings under Section 4915 R.S.  
no further action on claims 1-25 is taken at this time.

*AWC*

*D. O. Backus*  
Examiner.

u/64

#27-1184  
*Argument*



UNITED STATES PATENT OFFICE

Division 31.

Room 340-Annex.

Herold D. Arnold :

Serial No. 59,210 :

Filed Nov. 4, 1915 :

Invention: Thermionic Device and  
Method of Constructing and  
Operating the Same.

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

RECEIVED OFFICE

DEC 21 1924

DIVISION 31

In response to the Office action dated July 2, 1923, the Patent Office is respectfully asked to reconsider its rejection of Claims 24 to 28.

These claims have been rejected on what the applicant understands to be an alleged prima facie showing of public use. In reply, it will be pointed out (1) that the data to which the Examiner refers do not make a prima facie showing of public use; (2) that the alleged showing of public use on which the Examiner relies is vague and indefinite and should be specified more particularly, and (3) that the rejection is premature and a different procedure should be followed if the Office is to persist in the attitude indicated in the last Office action.

(1) Applicant's attorney is somewhat familiar with the testimony in the case to which the Examiner refers, namely General Electric Company v. Sargent Radio Company, No. 589 in the United States District Court for the District of Delaware. The attorney finds nothing in this testimony to anticipate the

4/65



claims here under discussion. These are not broad claims for amplifying, but are specific claims for amplifying in a particular way. These claims relate to amplifying with such a voltage adjustment that the current increments are proportional to the voltage increments over the range of current and voltage that is involved. This adjustment is not a necessity for amplifying but is an advantage. It may be that the testimony on which the Examiner relies contains disclosure of the practice of amplification more than two years before the present application was filed; but there is nothing in the testimony to show that any such amplification was practiced at the advantageous voltage adjustment which is expressly indicated in the claims.

(2) The record in the Delaware case on which the Examiner relies contains nearly 2000 pages of testimony in addition to several thousand pages of exhibit material. It is respectfully submitted that the Examiner should have made his reference to this testimony more particular. It is now requested that the Examiner take up at least one representative claim among the rejected claims and give particular page reference to the testimony on which he relies to show the steps recited in such claim. Especially it is asked that he point out the testimony on which he relies for the step of optimum adjustment of the voltage. It is believed that when a particular claim is considered step by step, in relation to particular pages or questions and answers of the printed record, it will become apparent that the testimony contains no disclosure of applicant's method in public use more than two years before his filing date.

(3) Attention is directed to the digest of the law relating to public use and public use proceedings, found on pages 12 to 20 of the book on "Patent Office Practice" by A. R. McCrady, published in 1928 by the H. D. Williams Company, Garay Building, Washington, D. C. If the Examiner believes that the testimony in the Delaware case makes a prima facie showing of public use, nevertheless it is premature to reject the claims. The proper procedure would be as stated at the bottom of page 14 and top of page 15 of the book referred to, namely to advise the Commissioner of the situation, whereupon, if the Commissioner adopts the Examiner's view, he will take steps to institute the usual "public use proceedings." See the cases cited in connection with the foregoing reference, and also see the bottom of page 252 and top of page 253 of "Underwood's Interference Practice" published in 1928 by Patent Law Publishing Company, Detroit, and the cases cited in connection with this reference.

Public use, as a basis for rejection, can only be established by testimony taken on notice to applicant and with opportunity to applicant to cross-examine witnesses and to produce testimony in reply. Hitherto, applicant has had no such opportunity to confront the witnesses and to cross-examine, still less to produce testimony in reply.

In regard to the "proceedings under Section 4915 R. S." mentioned in the Office letter, the case referred to in the Southern District of New York is still on the docket and has not yet been brought to trial.

The Delaware case to which the Examiner refers as having been decided by Judge Hugh M. Morris, is now pending



on appeal in the Circuit Court of Appeals for the Third Circuit. It is understood that it is expected to be argued in March or April, 1929.

For the reasons set forth above, it is respectfully submitted that Claims 26 to 32 are not properly rejected on the alleged public use to which the Examiner refers, and that these claims should be pronounced allowable.

Respectfully submitted,

HAROLD B. ARNOLD,

BY John R. [Signature]  
Attorney.

1188

Div. 51

Room 240-ANNEX

Address only  
The Commissioner of Patents,  
Washington, D. C.,  
and not any official by name

DEPARTMENT OF COMMERCE  
UNITED STATES PATENT OFFICE

Page 7c. 28

All communications respecting this  
application should give the serial number,  
date of filing, and name of  
the applicant

AWO:MEG

WASHINGTON September 20, 1929.

Please find below a communication from the EXAMINER in  
charge of this application.

*Thomas E. Robertson*  
Examiner in Charge of Patents

Applicant: H. DeF. Arnold

John G. Roberts,  
463 West Street,  
New York, N. Y.

Ser. No. 59,210  
Filed Nov. 2, 1915  
For Thermionic Devices and  
Method of Constructing and  
Operating the Same.

MAILED  
SEP 20 1929

Responsive to applicant's communication of  
December 20, 1928.

The rejection of claims 24-32 on the ground set  
forth in the Office action of July 2, 1928 is withdrawn  
in view of the lack of sufficient evidence proving public  
use of a high vacuum thermionic discharge device by De  
Forest to form an anticipation for the subject matter  
recited in the above claims.

Claims 24-32 are now rejected as failing to define  
invention over the issue of the interference in which  
this application has been involved. (See claim 25 for-  
merly claim 31).

In view of the proceedings under Section 4915 R.S.  
no further action on claims 1-25 is taken at this time.

*Five*

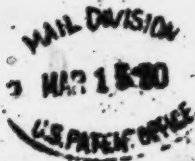
*E. D. Brown*  
Examiner



1189

#29

Argument



UNITED STATES PATENT OFFICE

Division 51

Room 240 Annex

Harold D. Arnold :

Serial No. 59,210

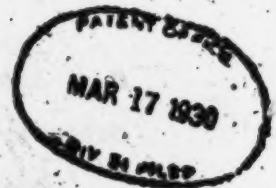
Filed November 2, 1915 :

Thermionic Devices and  
Inventions. Method of Constructing and  
Operating the Same.

COMMISSIONER OF PATENTS,

Washington, D.C.

Sir:



In response to the Office Action dated September 20, 1929, the Patent Office is respectfully requested to reconsider its rejection of Claims 25 to 32.

These claims have been rejected "as failing to define invention over the issue of the interference ....". As an example of the counts of that issue, the Examiner goes on to mention Claim 25, formerly 31.

All of the Claims 25 to 32 relate to the idea of establishing such a relation among the elements of the combination that amplification shall occur at the straightest part of the characteristic volt-ampere curve. This is a patentable improvement over the interference issue. Considering, for example, Claim 25 to which the Examiner has made reference, - according to this claim, operation might be anywhere along the characteristic curve, provided merely that it was "materially above ionization voltages". For example, so far as the interference issue is concerned, operation might be well up on the "knee" of the characteristic curve. This might give considerable distortion, but nevertheless it would answer to Claim 25; it would give "control

[of] said current in a stable and reproducible manner".

Now applicant comes along with a patentable improvement by which the distortion that would occur in such a case is avoided. This improvement is explicitly defined in the claims under rejection, and is not hinted at in any one of the claims of the interference issue. The improvement referred to lies in establishing such a relation that the operation of the tube as an amplifier is at the straightest part of the characteristic curve.

Accordingly, it is respectfully submitted that the said rejected Claims 26 to 32 should be allowed, and favorable action at an early date is requested.

In regard to the proceeding under §4915 R.C. in the Southern District of New York, the case referred to is still on the docket and has not yet been brought to trial. If the outcome of this case should be favorable to the present applicant, it will obviously remove the ground of rejection on which the Examiner relies in the last Office Action. But applicant's contention is that he is entitled to Claims 26 to 32 whichever way the case is decided in the Southern District of New York.

In regard to the case pending in Delaware which was mentioned by the Examiner in Paper No. 26, dated 7/2/28, the appeal on this case was argued in Philadelphia early in the year 1929. Thereafter decision was given by the U. S. Circuit Court of Appeals for the Third Circuit, in favor of the defendant. Plaintiff petitioned for a rehearing, and on December 2, 1929, the Court granted its petition and the case is set for argument on or about April 1st, 1930.

Respectfully submitted,

HAROLD D. ARNOLD,

By J. H. Smith

MAR 14 1930



119b

Div. 51

Form 240-ANNOX

Page No. 32

Address only  
The Commissioner of Patents  
Washington, D. C.  
and not any other office

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON

December 8, 1930.

AMU:MDG

Please find below a communication from the EXAMINER in charge of this application.

*Thomas E. Roberts*  
Commissioner of Patents

GPO 11-4225

John G. Roberts,  
465 West Street,  
New York, N. Y.

Applicant: H. R. Arnold

Ser. No. 59,210  
Filed Nov. 2, 1915  
For Thermionic Devices and  
Method of Constructing and  
Operating the Same

Responsive to applicant's communication of  
March 15, 1930.

The general purport of applicant's argument,  
above-mentioned, is noted. It is not thought,  
however, that anything can be gained by taking  
further action on the merits of claims 24-32 until  
such time as the proceedings under Section 4915 U.S.  
involving claims 1-23 are terminated.

Following the practice in Ex Parte McDermick  
115 O. G. 2506 further action by the Office is  
accordingly suspended on claims 24-32 as well as  
claims 1-23.

If applicant, however, insists upon further  
action by the Office in the future, it will be  
given, but in any case, it is expected that appli-  
cant will keep the examiner informed as to the de-  
velopments in the above-mentioned proceedings and  
notify the Office immediately upon the termination  
of said proceedings.

uue.

59-101

*[Signature]*  
Examiner

1192

PAPER NO. 33  
LETTER

## UNITED STATES PATENT OFFICE

Division 51

Room 840-Annex

H. D. Arnold :  
 Serial No. 59,210 : Invention: Thermionic Devices and  
 Filed Nov. 2, 1915 : Method of Constructing  
 and Operating the Same

COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:



In response to the Office action dated December 2, 1930, and supplementing the last two paragraphs of applicant's communication filed March 15, 1930, the following information is submitted:

As to the case pending in United States District Court in Delaware, and mentioned by the Examiner in Paper No. 26, dated July 2, 1932; after decision on appeal affirming the Delaware Court in favor of defendant, the case was re-heard by the Court of Appeals of the Third Circuit and decided, in favor of plaintiff. Then on a writ of certiorari it was carried to the United States Supreme Court, which reversed the Court of Appeals, deciding in favor of defendant. The opinion was published in 406 U. S. 228. On October 19, 1931, the Supreme Court denied a petition for re-hearing and amended its opinion in connection with its earlier decision.

On November 10, 1931, the bill in the case under R. 3. Section 4915 in the Southern District of New York was dismissed without prejudice, in accordance with a stipulation

64/73



1193

between the parties.

This letter is written especially to meet the last part of the last paragraph of the Office letter of December 8, 1930 "it is expected that applicant will keep the Examiner informed.....".

Respectfully submitted,

H. B. ARNOLD

NOV 17 1931

*H. B. Arnold*  
Attorney

-3-3-

Pat. 51

Form 5028

Paper No. 54

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The Commissioner of Patents  
Washington, D. C.  
and not any other office

## DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

AWO:MOG

WASHINGTON

Mar. 31

All communications respecting this  
application should be addressed to the  
Commissioner of Patents, Department of  
Commerce, Washington, D. C.

Please find below a communication from the EXAMINER in  
charge of this application.

*James E. Robertson*  
Commissioner of Patents

Applicant: *Dev. Arnold*

John C. Roberts,  
465 West Street,  
New York, N. Y.

Ser. No. 59,212  
Filed Nov. 2, 1906  
For Thermionic Devices and  
Method of Constructing and  
Operating the Same.

Responsive to letter of November 18, 1931.

Pursuant to the information furnished by appli-  
cant in the above-mentioned letter in regard to the  
termination by dismissal of the proceeding under R.S.,  
Sec. 4915 in the United States District Court for the  
Southern District of New York, the following ex parte  
action is taken in this case:

Claims 1-25 corresponding respectively to claims  
1, 4-10, 12-15, 17 and 20-31 referred to in the Office  
action of September 14, 1925, stand rejected for rea-  
sons stated in that action.

Claims 26-32 are again rejected for reasons stated  
in the Office action of September 20, 1929.

This action is made final.

*L. P. McEwen*  
act Examiner

6475

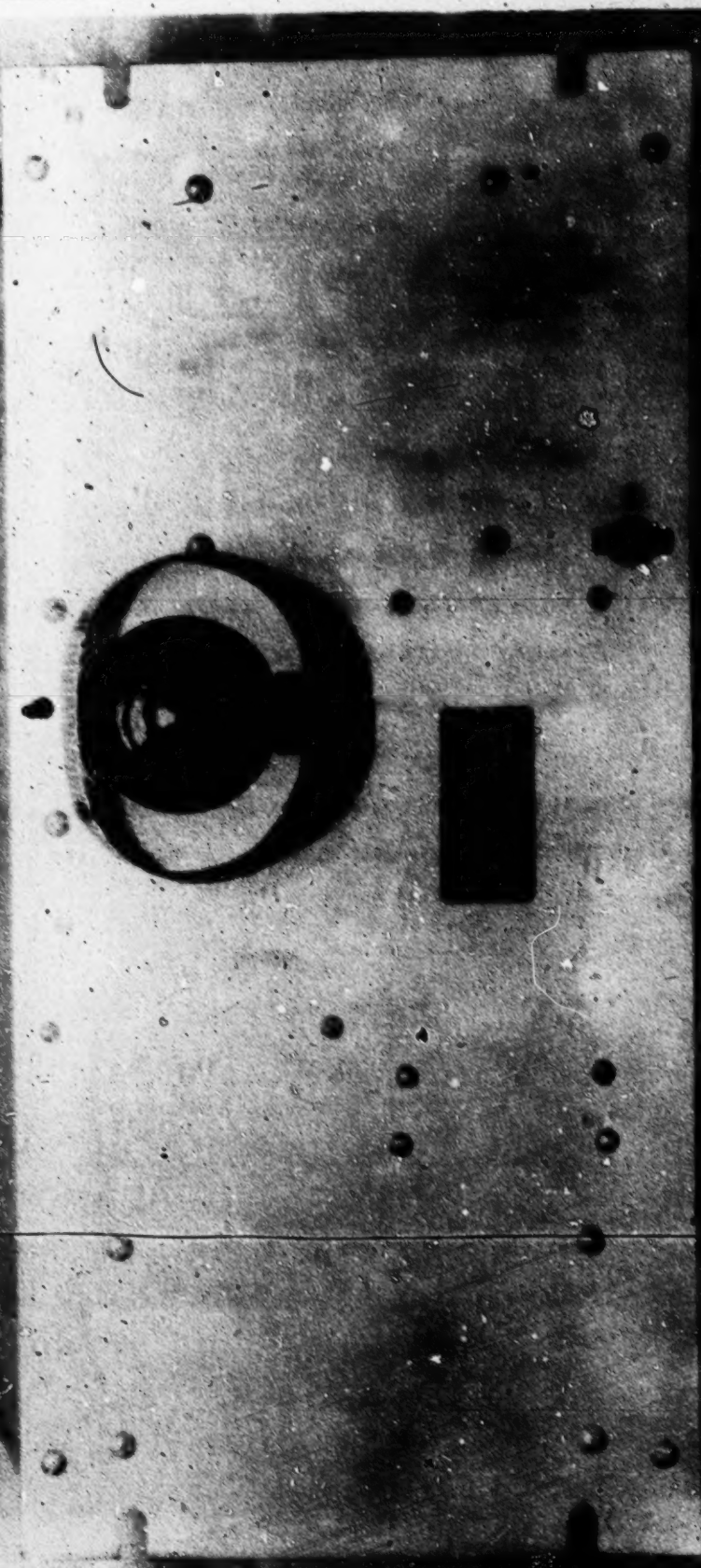


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## PLAINTIFF S' EXHIBIT No. 73

Group of ten photographs of the defendant's amplifiers





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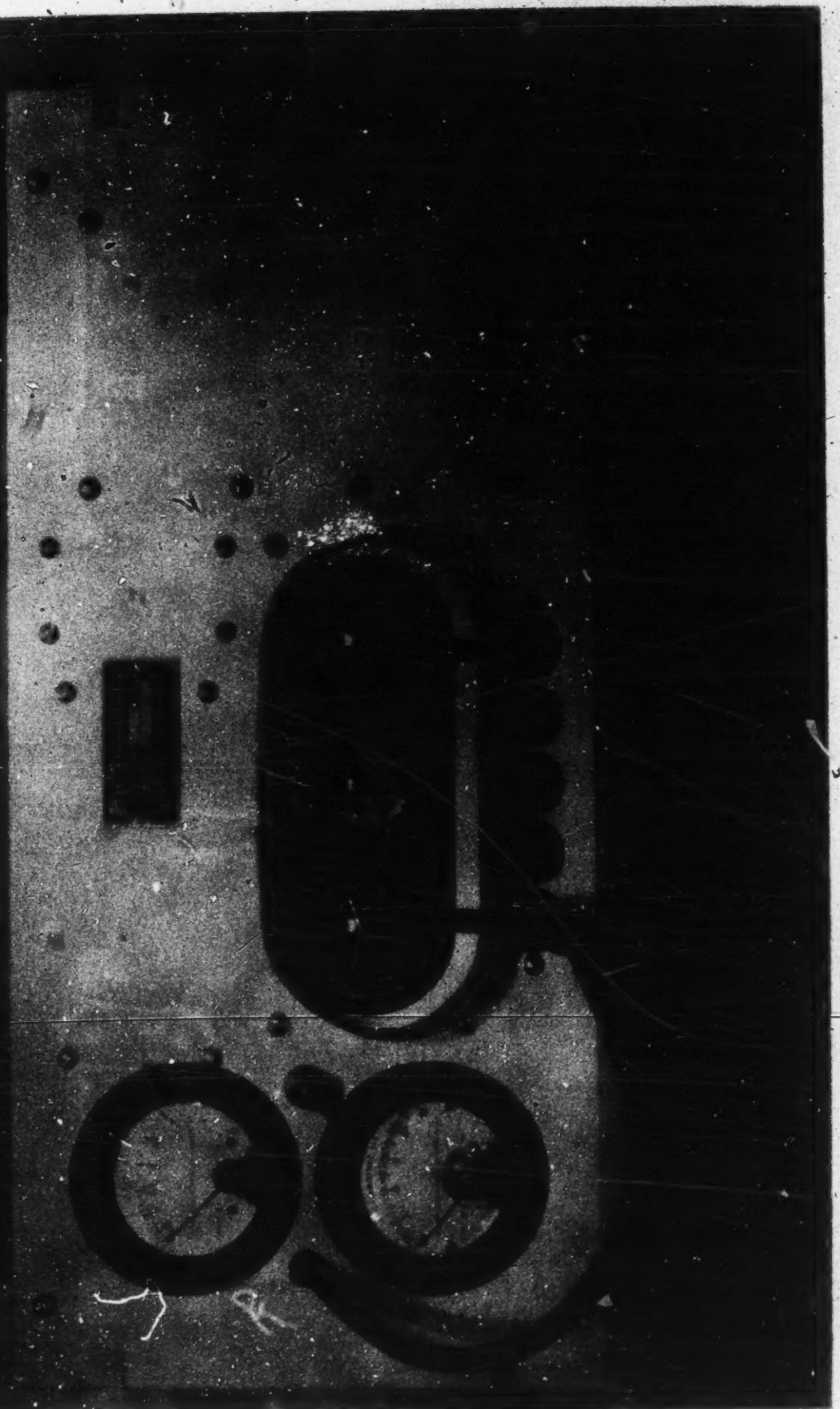
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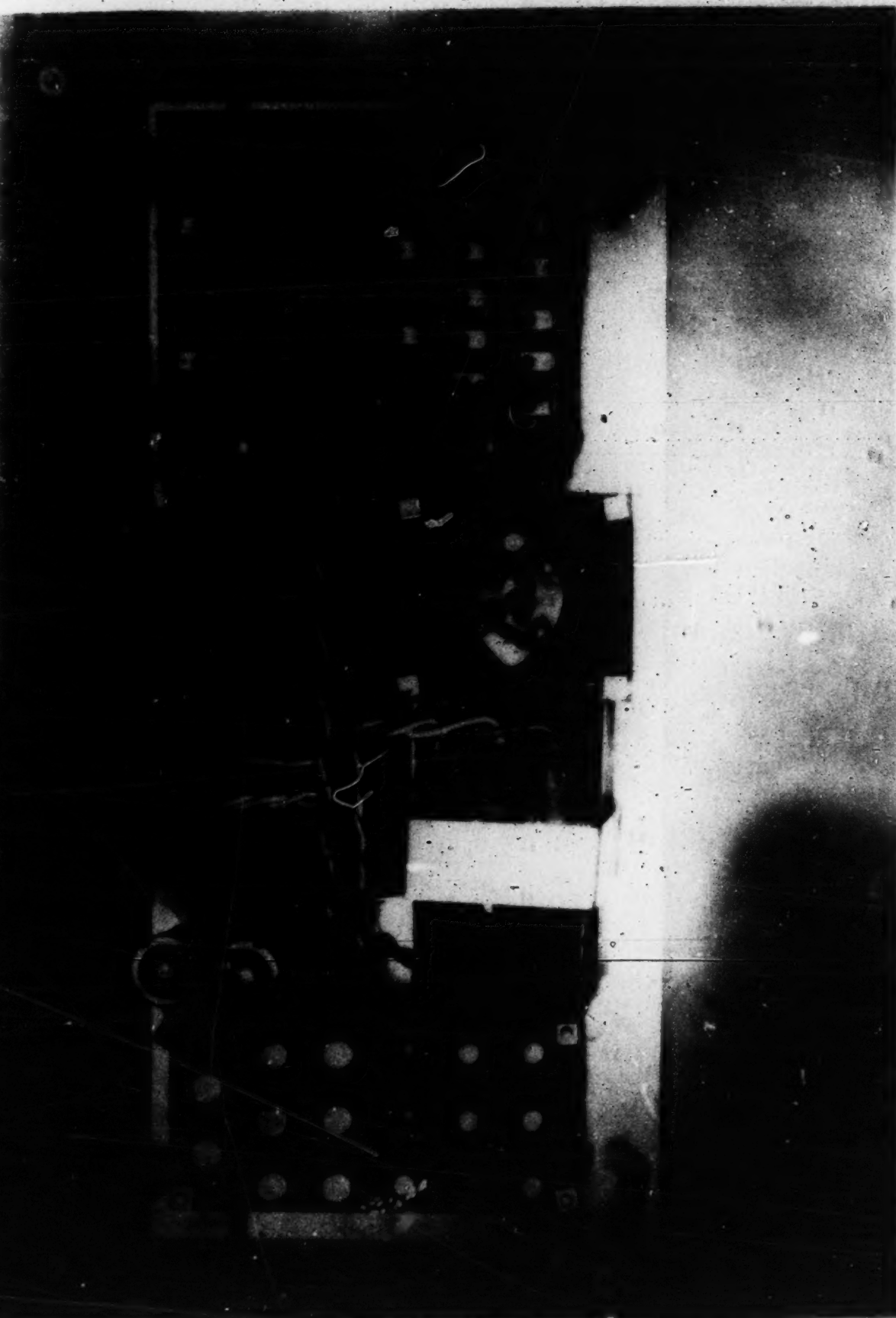




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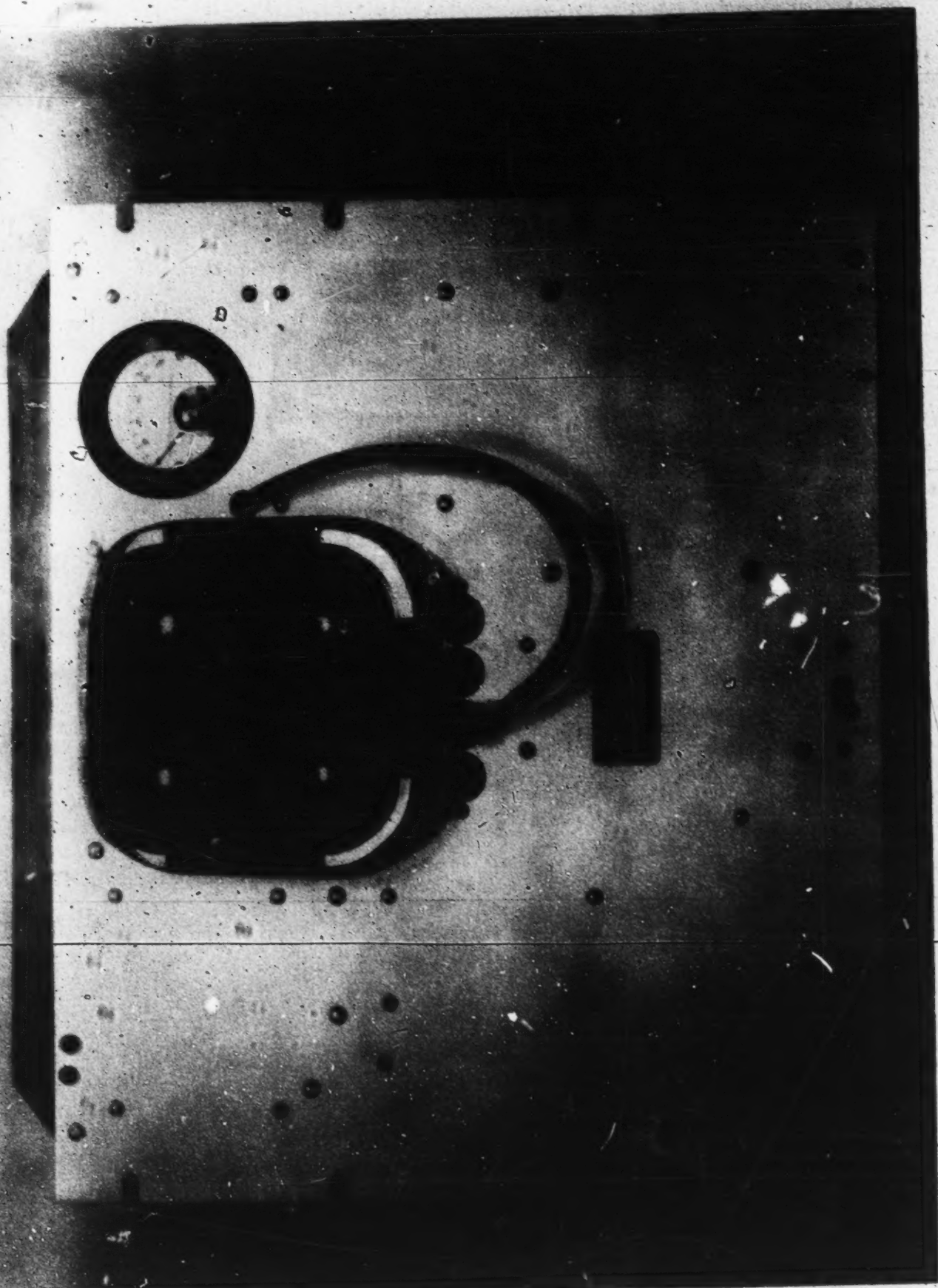
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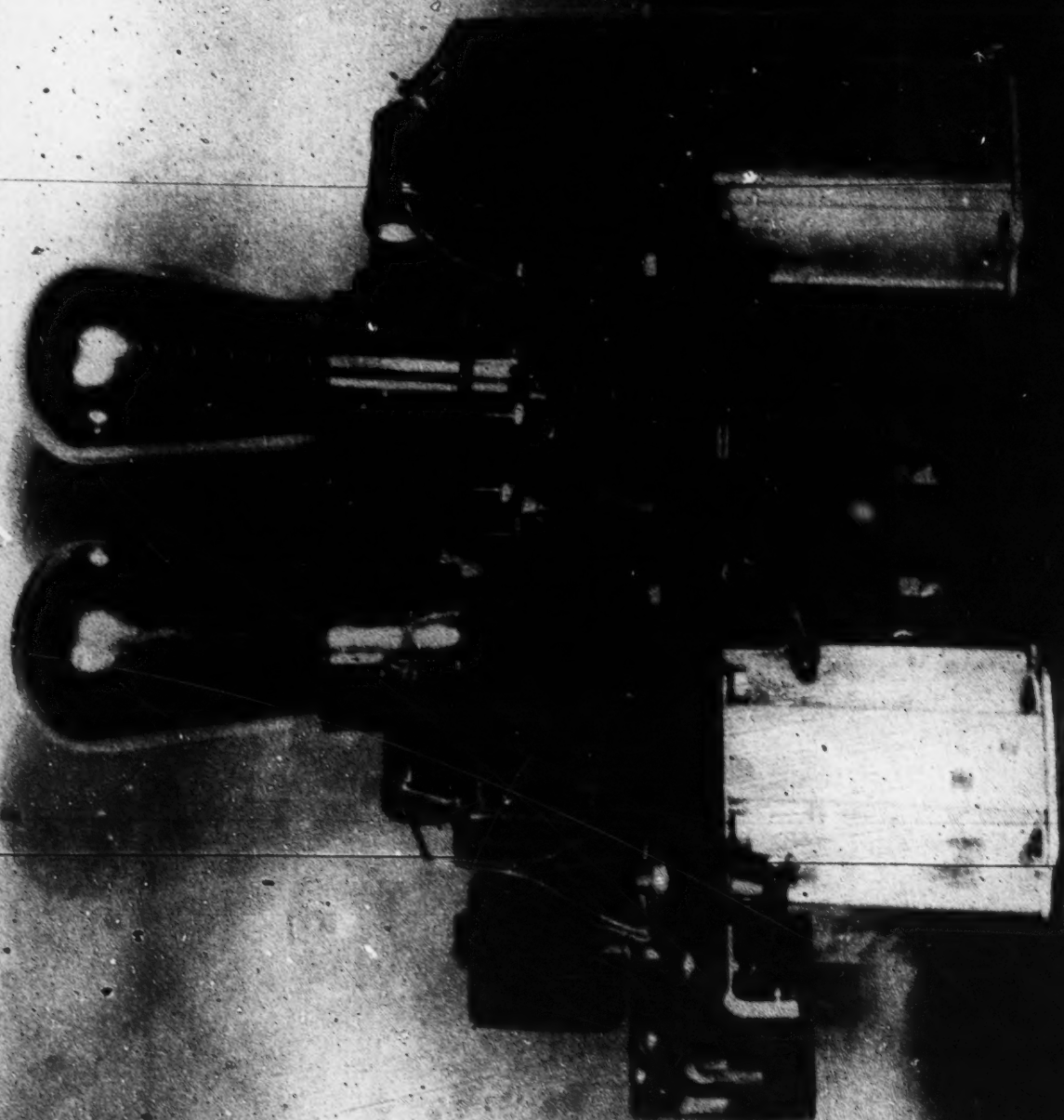




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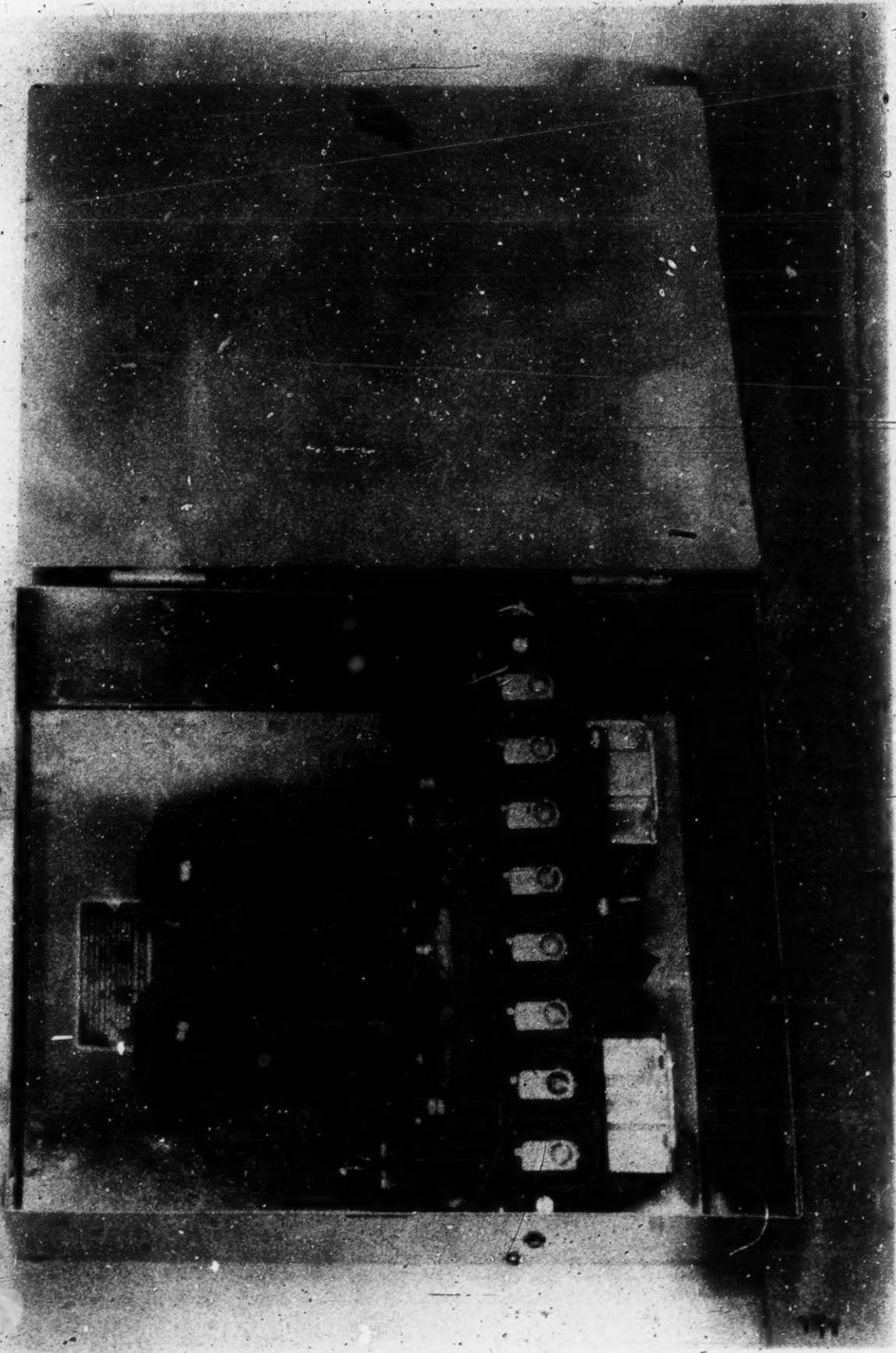
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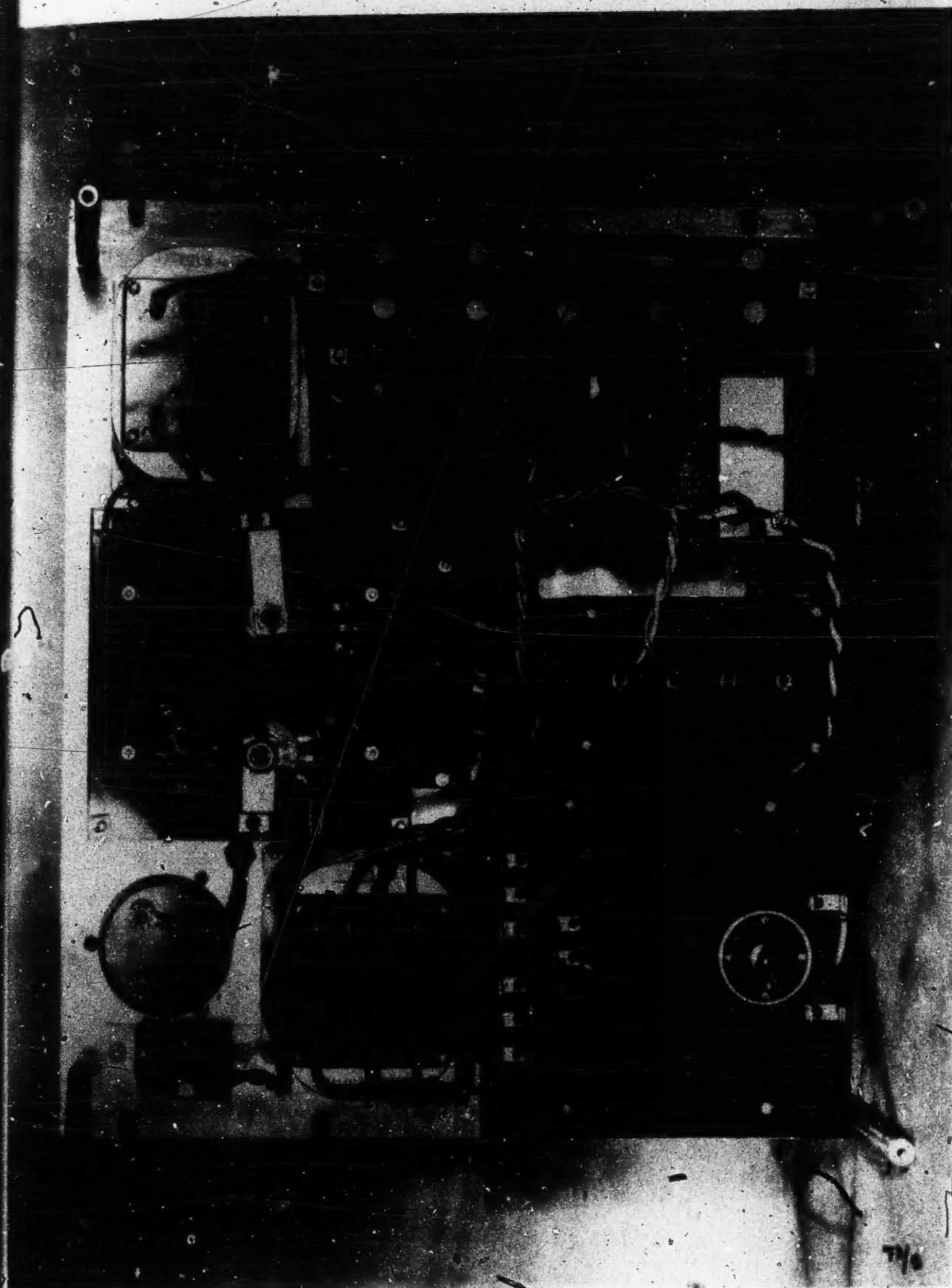
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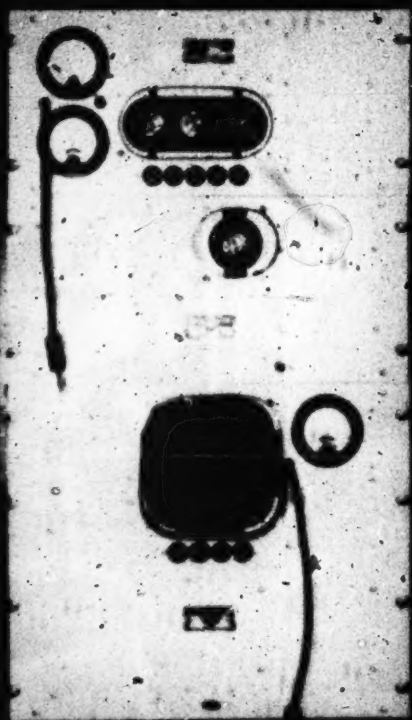




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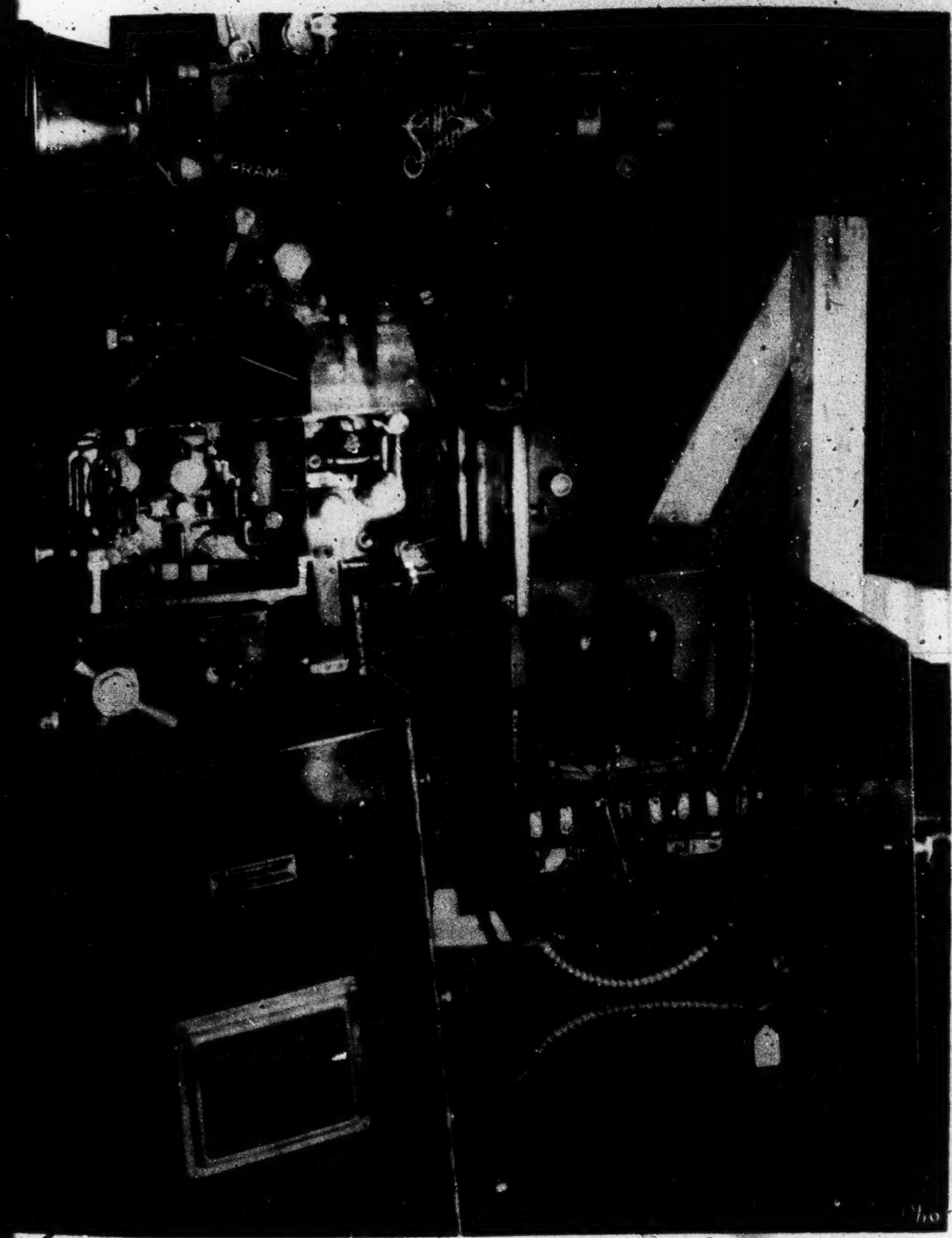
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**Plaintiffs' Exhibit No. 74.****DEFENDANT'S EXHIBIT No. 66-F.**

**AMERICAN TELEPHONE AND TELEGRAPH COMPANY  
Bell System**

195 Broadway  
New York, November 6, 1926.

**MR. EDGAR S. BLOOM, President  
Western Electric Company, Incorporated,  
195 Broadway, New York, N. Y.**

3614

**DEAR MR. BLOOM:**

The American Telephone and Telegraph Company extends to the Western Electric Company, Incorporated, the privilege of manufacturing for sale or lease in the United States, systems and apparatus for recording and reproducing sound in coordination, synchronism or timed relation with the taking and projection of pictures and of entering into contracts with properly accredited individuals or organizations for the use by them of such systems and apparatus in the United States. This release is subject to restrictions as follows:

3615

1. That the Western Electric Company, Incorporated, pay to the American Telephone and Telegraph Company a 5% royalty on its sale price. The same royalty shall also apply on all parts for repair or reconstruction where such parts are in the classification of restricted apparatus but shall not apply on other parts which



3616

*Plaintiffs' Exhibit No. 74.*

are classed as standard unrestricted apparatus.

2. That the Western Electric Company, Incorporated, furnish this equipment to the Associated Bell Telephone Companies at prices which shall be as low as the Electric Company's prices, under comparable conditions, to its most favored customers, in effect on the date of shipment.

3617

3. That the Western Electric Company, Incorporated, pay to the American Telephone and Telegraph Company  $33\frac{1}{3}$  per cent. of the gross royalties and/or other payments received by the Western Electric Company for the use of these systems and apparatus in the United States.

3618

4. That the manufacture, sale, lease and use of these systems and apparatus shall not be other than in accordance with the conditions of the License Agreement of July 1, 1920 between the General Electrical Company and the American Telephone and Telegraph Company as Modified by the Agreement dated July 1, 1926.
5. That the Western Electric Company, Incorporated, shall extend no rights covering the use of such systems and apparatus in connection with a wire distributing system except for apparatus for distribution to an assembled audience or to rooms (other than "homes") within a building or a group of substantially adjacent build-

ings commonly owned or operated, in each case located in the immediate vicinity of such audience or within the building or group of buildings within which such distribution is made:

6. That the American Telephone and Telegraph Company shall approve the form of contract to be entered into between the Western Electric Company and its customers or lessees which shall provide in particular—

3620

(a) That said apparatus shall not be used for any other purpose than the recording and reproducing of sound in coordination, synchronism or timed relation with the taking and projection of pictures.

(b) That such licenses under patents of the American Telephone and Telegraph Company and of the Western Electric Company, Incorporated, as are extended by the latter shall be non-exclusive to at least the extent that non-exclusive rights under any and all such patents shall be reserved by the American Telephone and Telegraph Company and its Associated Companies.

3621

The American Telephone and Telegraph Company also now withdraws the release to the Western Electric Company, Incorporated, covered by Mr. Gifford's letter to Mr. DuBois dated July 6, 1925.

(Sgd.) W. S. GIFFORD

Sincerely yours,

President.



3622

Plaintiffs' Exhibit No. 75.

## Copies to:

E. S. Bloom  
 H. A. Halligan  
 F. B. Jewett  
 J. L. Kilpatrick  
 E. B. Craft (2)  
 J. W. Bancker (5)  
 F. B. Gleason  
 C. I. DeWitt (3)  
 D. C. Tanner  
 R. H. Greogory  
 G. C. Pratt  
 E. P. L. Pelly  
 C. J. McCarthy  
 L. D. Gruman (2)

3623

Plaintiffs' Exhibit No. 75.LICENSE

3624

WHEREAS, the undersigned American Telephone and Telegraph Company, a New York corporation, is the owner of certain United States patents, and rights to and under patents, relating or applicable to systems and apparatus for recording sound and to systems and apparatus for the reproduction of sound from records thereof, including the patents listed in the schedule hereto attached and marked Schedule A; and

WHEREAS, Western Electric Company, Incorporated, a New York corporation, and Electrical Research Products, Inc., a Delaware corpora-

tion, are now engaged in making, selling, leasing, installing and using apparatus for recording sound and apparatus for reproducing sound from records thereof, by virtue of licenses from said American Telephone and Telegraph Company under said patents for certain uses or fields of business and desire to continue such business and to exclude infringers of the said patents from said field of business.

Now, THEREFORE, in consideration of One Dollar and other good and valuable consideration, receipt of which is hereby acknowledged, and of the royalties heretofore paid and agreed to be paid under the aforesaid licenses, the American Telephone and Telegraph Company hereby confirms the aforesaid licenses to Western Electric Company, Incorporated, and Electrical Research Products Inc. and does hereby assign and set over to said Western Electric Company, Incorporated, and Electrical Research Products Inc. all the rights which it now has or may hereafter have under or arising from said patents or any of them (specifically including without excluding others each and all of the patents listed in said Schedule A) to exclude others from the manufacture, sale, lease, installation and/or use of apparatus, devices, systems or methods

3626

3627

(1) for the recording of sound for the production of sound records:

(a) for sale to the public as phonograph records, or

(b) for use in connection with the exhibition of pictures, except in the home;



3628

Plaintiffs' Exhibit No. 75.

(2) for the reproduction of sound from sound records:

- (a) as a public performance, or
- (b) in connection with the exhibition of pictures, except in the home;

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and for the same consideration the American Telephone and Telegraph Company assigns and sets over to said Western Electric Company, Incorporated, and said Electrical Research Products, Inc. all claims recoverable in law or in equity, whether for damages, profits, savings, or of any other kind or description which the American Telephone and Telegraph Company now has or may hereafter have arising out of the infringement of the aforesaid patents within said field; the intention being that in so far as concerns the exclusion of infringers of said patents from the aforesaid field of business, Western Electric Company, Incorporated, and Electrical Research Products Inc. shall be vested with as full rights in the premises as American Telephone and Telegraph Company would have had had this assignment not been made, including the right for their own benefit, to bring suit on said patents or any of them, either at law or in equity, against infringers in said field of business to exclude such infringers from practicing the inventions of said patents, and for their own use and benefit to collect damages which may arise by reason of the future infringement of said patents by infringers within said field of business, but nothing herein contained shall in any way affect or alter the rights of American Telephone and Telegraph Company

*Plaintiffs' Exhibit No. 75.*

3631

against others than infringers within the afore-  
said field.

AMERICAN TELEPHONE AND  
TELEGRAPH COMPANY

By (Sgd.) WALTER S. GIFFORD  
President

New York, N. Y.,  
May 7, 1929.

## SCHEDULE "A"

3632

<i>Inventor</i>	<i>Patent No.</i>	<i>Date of Issue</i>	<i>Subject-Matter</i>
E. H. Colpitts	1,128,292	Feb. 16, 1915	Electric-Wave Amplifier
H. D. Arnold	1,129,942	Mar. 2, 1915	Gaseous Repeater in Cir- cuits of Low Impedance
L. De Forest	1,201,272	Oct. 17, 1916	Telegraph and Telephone Receiving System
F. Lowenstein	1,231,764	July 3, 1917	Telephone-Relay
L. De Forest	1,314,250	Aug. 26, 1919	Method of and Means for Reproducing and Ampli- fying weak Pulsating Currents
H. D. Arnold	1,329,283	Jan. 27, 1920	Thermionic Amplifier
H. D. Arnold	1,349,252	Aug. 10, 1920	Method of and means for Utilizing Thermionic Currents
L. De Forest	1,375,447	Apr. 19, 1921	Means for Amplifying Currents
L. De Forest	1,377,405	May 10, 1921	Audion-Circuit
H. D. Arnold	1,398,665	Nov. 29, 1921	Thermionic Amplifier
H. D. Arnold	1,403,475	Jan. 17, 1922	Vacuum Tube Circuits
R. C. Mathes	1,426,754	Aug. 22, 1922	Circuits for Electron- Discharge Devices
R. A. Heising	1,432,022	Oct. 17, 1922	Circuit connection of Electron Discharge apparatus

3633



3634

Plaintiffs' Exhibit No. 76.

<i>Inventor</i>	<i>Patent No.</i>	<i>Date of Issue</i>	<i>Subject-Matter</i>
R. C. Mathes	1,442,439	Jan. 16, 1923	Vacuum-Tube Repeater
H. D. Arnold	1,448,550	Mar. 13, 1923	Thermionic Amplifier Circuits
H. D. Arnold	1,465,332	Aug. 21, 1923	Vacuum-Tube Amplifier
D. G. Blattner	1,483,273	Feb. 12, 1924	Circuit for Heating the Filaments of Audions
D. G. Blattner	1,493,595	May 13, 1924	Amplifying with Vacuum Tubes
3635 H. D. Arnold	1,504,537	Aug. 12, 1924	Power-Limiting Amplify- ing Device
H. D. Arnold	1,520,994	Dec. 30, 1924	Electron-Discharge Amplifier
E. O. Scriven	1,544,943	July 7, 1925	Electric Wave Repeater for Multi- plex Transmissions

Plaintiffs' Exhibit No. 76.

WARREN F. HUBLEY      Telephone Terrace 4444  
Pres. & Gen'l. Mgr.      4445

3636

AMERICAN TRANSFORMER COMPANY  
Makers of Electrical Appliances  
174-188 Emmet St., Newark, N. J.

September 13, 1927

(Dictated 9/12/27)

Mr. Ira J. Adams,  
Patent Department,  
Radio Corporation of America,  
#233 Broadway,  
New York City.

Dear Sir:

In attempting to market power supply and  
amplifier units and to sell them to manufacturers

for use in conjunction with other devices, we are frequently confronted with the question as to whether or not our license agreement on these devices permits their use with anything except a radio broadcast receiver.

In accordance with the license agreement, we are permitted to manufacture and sell only for radio amateur reception, radio experimental reception, and radio broadcast reception; but we have several inquiries for power amplifiers for use with a combination radio receiver and phonograph pick-up. We have one inquiry which is somewhat urgent for an amplifier to be used for a combination phonograph pick-up and motion picture machine. In this particular device, there will be no radio receiver.

3638

Several weeks ago this matter was discussed with Mr. Norton of your Patent Department over the telephone, as you could not be reached at that time. Our prospective customer is very anxious to get started, but is unwilling to proceed or to place orders with us until we can obtain from the Radio Corporation a statement as to whether the license agreement can be extended to incorporate the use of power amplifiers with devices other than radio receivers or in combination with radio receivers.

3639

Your early reply will be greatly appreciated.

Yours very truly,

AMERICAN TRANSFORMER COMPANY

J. L. SCHERMERHORN

Chief Engineer.

JLS:CMB/.



3640

*Plaintiffs' Exhibit No. 76.*

September 16th, 1927.

American Transformer Company,  
174 Emmet Street,  
Newark, N. J.

Gentlemen:

3641

I have your letter of September 13th. Your license permits you to sell power supply and amplifier units for radio use only. The units sold by you are not licensed for electric phonograph work nor any other work outside of radio. No one has yet had licenses under our patents to make electric phonographs, or combined radio sets and electrical phonographs, except, of course, we do sell apparatus to the Victor Company that is made into combined radio receiving set and electric phonograph, but this is apparatus made by ourselves. In view of this, people who make electric phonographs or make combined radio sets and electric phonographs are infringers of whatever patents of ours are involved.

3642

The net result of this is that if anyone buys a power supply or amplifier unit from you, he may use it for a radio receiving set but he cannot use it for an electric phonograph, nor can he use it for a combined phonograph and radio set.

A number of our licensees have been requesting that they be given authority to sell the power supply unit for phonograph purposes but we have declined to extend the license in the way requested, as we feel we cannot do this at the present time at least.

Very truly yours,

LJA:CF

## PLAINTIFF S' EXHIBIT No. 77

- Item 1 Letter from Radio Corporation to American Transformer Company of December 18th, 1930 and attached Schedules A and B
- Item 2 Letter of American Transformer Company to Radio Corporation, dated January 5, 1931
- Item 3 Letter of Radio Corporation to American Transformer Company, dated April 17, 1931
- Item 4 Letter of Arthur Young & Company to Radio Corporation of America of May 15th, 1931
- Item 5 Letter of Radio Corporation of America to American Transformer Company of June 10, 1931 and attached schedule
- Item 6 Letter of Radio Corporation to American Transformer Company of June 22, 1931
- Item 7 Letter of Radio Corporation to American Transformer Company of December 30, 1931 and attached schedules A, B, C and D
- Item 8 Letter of Radio Corporation to American Transformer Company of January 7th, 1932
- Item 9 Check of Radio Corporation of America to American Transformer Company, dated December 9, 1930; both face and back, the check showing endorsements
- Item 10 Check of Radio Corporation of America to American Transformer Company of June 4, 1931; both face and back showing endorsements.



December 18, 1930.

## Item 1.

American Transformer Company,  
174-188 Emmet Street,  
Newark, New Jersey.

Gentlemen:

We have considered the summary as submitted of your sales for the third quarter of 1930 (July, August and September) under the power amplifier and supply license agreement. It is entirely evident to us, and must be equally evident to you, from a consideration of the names of your customers that practically all of such sales have been made to companies which intend to use the apparatus for purposes other than that for which it is licensed, namely, amateur reception, experimental reception and broadcast reception as such terms are defined in the license agreement.

We, therefore, are unwilling to accept your check of \$6,018.79 tendered to cover the royalty for this quarter and it is accordingly returned herewith. In lieu thereof, please send us a check for royalties on sales made for licensed uses only. The list shown on the attached Schedule "A" covers, we believe, the only items likely to have been sold for uses under said license.

We have also examined your prior statements commencing with July 15, 1930, and find that most of the items therein likewise have been sold to concerns that obviously do not intend to use them for the licensed purposes. The attached list entitled Schedule "B" indicates the sales likely to have been made within the licensed field. We return herewith our check for \$14,534.56 to cover a refund of the royalties on the remainder which have obviously been sold for uses not within said license. Corresponding refunds will also be made for sales for unlicensed uses during prior periods upon receipt of appropriate summaries of your sales for such periods.

The sale of apparatus for unlicensed uses is an infringement of the patents covering the apparatus. We must protest and insist upon immediate discontinuance of such sales for uses such as for public address systems or in connection with talking motion pictures.

We also take this occasion to notify you that we reserve the right to take appropriate action against your company and/or your customers for infringement arising out of unlicensed manufacture, use and/or sale.

Yours very truly,



SALES MADE BY AMERICAN TRANSFORMER CORPORATION  
DURING 3RD QUARTER OF 1930.

<u>1930</u>	<u>Sold To:</u>	<u>Quantity</u>	
August 5.	Vaughan Elect.	1	\$50
" 8	Wilmington Elec. Spec.	1	300
" 8	C. E. Deane	1	300
Sept. 29	M. & H. Sptg Goods	1	87
		<hr/>	
		4	740
		<hr/>	

Royalty at 7 1/2%.....\$50

## SCHEDULE "B"

SALES MADE BY AMERICAN TRANSFORMER CORPORATION  
FOR YEAR ENDED JUNE 30, 1930.

1929		Sold To:	Quantity	Sales	Returns	Royalty
July	13	Dr. I. Litse	1	\$261.00		
"	11	Best Mfg. Co.	1	425.00		
"	18	" "	1	425.00		
"	25	" "	1	425.00		
"	5	Wm. Rickey	1	52.00		
"	5	" "	2	114.00		
"	17	Triple Reflecting Arc Lamp	1	56.00		
"	17	" "	1	57.00		
"	24	Biophone Corporation	1		57.00	
"	24	" "	1		36.00	
Aug.	20	Moffett	1	410.00		
"	13	Theo. Christoualis	1	56.00		
"	13	" "	1	57.00		
"	30	Westinghouse Electric	1	57.00		
Sept.	18	Walthal	1	56.50		
			12	2,397.50	93.00	
				93.00		
				2,504.50		172.84
Oct.	11	Marks Brothers	1	62.50		
"	17	A. A. Ealen	1	52.00		
"	18	Wholesale Radio Service	1	58.50		
"	21	Platter Cabinet	2	110.00		
"	21	" "	1	240.00		
"	23	G. Wickizer	1	65.00		
"	15	M. De Vichi	1	40.00		
"	24	Perry Smith	1	36.00		
"	24	" "	1	56.50		
"	24	M. De Vichi	1	65.00		
"	29	Platter Cabinet	1	240.00		
"	31	Doolayphone Company	1	375.00		
"	5	Penn. Storage Battery Co.	1	540.00		
"	7	R. B. Scribner	1		36.00	
"	7	" "	1		57.00	
Nov.	7	S. Baraf	1	720.00		
"	7	" "	1	270.00		
"	15	J. A. Adams	1	270.00		
"	21	Doolayphone Company	1	600.00		
"	1	Wholesale Radio Supply	1		57.00	
"	3	Blum	1		36.00	
"	16	Marks Brothers	1		62.50	
"	26	Powers Cinsphone	1		546.00	
Dec.	5	International Research	1	500.00		
"	5	" "	1	139.00		
"	21	Radio Service Company	1	65.00		
"	21	" "	1	40.00		
"	10	Hammerlund Roberts	1	36.00		
"	10	" "	1	56.50		
"	16	Amr. Tel. & Tel. Co.	1	40.00		
"	16	" "	1	65.00		
"	26	Delta e/o Duncane Co.	1	40.00		
"	26	" "	1	65.00		
"	6	A. A. Ealen	1		52.00	
"	18	Platter Cabinet	2		110.00	



1220

<u>1929</u>	<u>Sold To:</u>	<u>Quantity</u>	<u>Sales</u>	<u>Balance</u>	<u>Pay</u>
Brought Forward		19	4 851.85	\$997.15	
Dec. 18	Platter Cabinet	8		480.00	
		17	4 851.85	1 437.15	
			1 437.15		
			<u>3 414.80</u>		
<u>1930</u>					
Jan. 9	Radio Shop of Newark	1	340.00		
" 24	Western Radio Mfg.	1	55.00		
" 30	Sentry Safety Control	1	40.00		
Feb. 14	Thos. V. Gould	1	275.00		
" 7	T. Southwell	1	38.00		
" 7	"	1	55.00		
" 4	Wholesale Radio Service	1	55.00		
" 4	"	1	55.00		
" 10	"	1	55.00		
" 17	"	1	55.00		
" 17	"	1	35.00		
" 1	M. & H. Sporting Goods	1		40.00	
" 1	"	1		85.00	
March 3	Otis Elevator Company	1	215.00		
" 3	Audiphone Corporation	1	62.50		
" 18	D. Mackintosh & Son	1	55.00		
" 18	"	1	55.00		
" 24	"	1	240.00		
" 1	Wholesale Radio Service	1		35.00	
		13	1,548.00	140.00	
			140.00		
			<u>1,408.00</u>		
Apr. 9	J. L. Moffett	1	500.00		
" 14	Mokey Corporation	1	125.00		
" 30	"	1	112.50		
May 12	E. M. Telong	1	540.00		
" 15	J. V. Moffett	1	600.00		
" 16	E. M. Telong	1	270.00		
" 15	J. A. Thomas	1	195.00		
June 30	Goodall Elec.	1	62.50		
		8	2,805.00		
			<u>2,805.00</u>		
	<u>GRAND TOTAL</u>		<u>9,350.00</u>		

Platt. Ex.-77, Item 2.

Transformer  
Specialists

O'Donnell 3-4244

Amplifier  
Equipment

## AMERICAN TRANSFORMER COMPANY

176 Nassau St.

Newark, N. J.

January 5, 1931.

Platt. Ex. 77-22

Radio Corporation of America,  
570 Lexington Avenue,  
New York, N.Y.

Gentlemen: Attn: Mr. H.C. Grover, Patent Attorney

We are in receipt of your favor of December 31st, returning the checks, and giving us the lists on which royalty is due, and are enclosing our check No. 3267 amounting to \$1,079.24, covering schedules A.B.C. & D., referred to in your letter.

We trust you will find this correct, and remain,

Yours very truly,

NR/REG.

AMERICAN TRANSFORMER COMPANY

ENCL: CHECK.

Mr. Grover

Royalty calculated  
correctly and check depositedJ.H. Maciel  
1/6/31



Pltff. Ex. 77, Item 3.

April 17, 1931

Mr. C. F. Loughhead, President  
American Transformer Company  
174 Emmet Street  
Newark, N. J.

Dear Mr. Loughhead:

This will introduce Mr. C.  
S. Brison of Arthur Young & Company whom we  
have assigned to take up the examination of  
your books and accounts as per the License  
Agreement dated February 1, 1927.

Yours very truly,

ECA/QM

Pltff. Ex. 77, Item 4.

## ARTHUR YOUNG &amp; COMPANY

ACCOUNTANTS AND AUDITORS

1 CEDAR STREET

NEW YORK

May 15, 1931

ABLE ADDRESS "ARTHYOUNG"

NEW YORK  
CHICAGO  
PITTSBURGH  
KANSAS CITY  
MILWAUKEE  
LOS ANGELES  
DALLAS  
DETROIT  
TULSA  
LONDON, ENGLAND  
PARIS, FRANCE

RECEIVED

MAY 15 1931

License Division

pay En it

Mr. Ewen C. Anderson,  
License Administrator,  
Radio Corporation of America,  
570 Lexington Avenue,  
New York City.

Dear Mr. Anderson:-

AMERICAN TRANSFORMER CO.

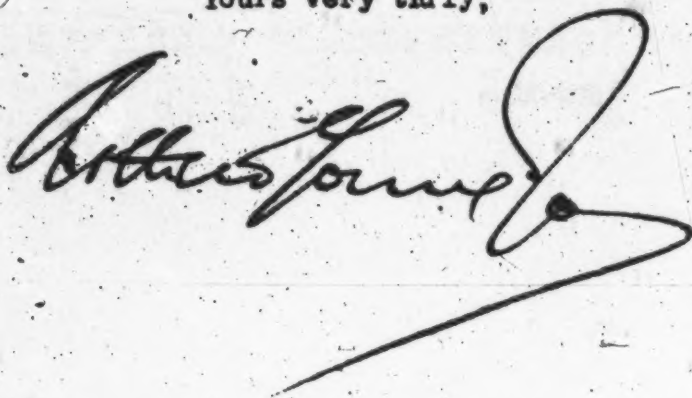
We take pleasure in enclosing three (3) copies of our report on the Royalties payable by the above Company under License agreement from February 1, 1927 to March 31, 1931.

We return to you the Licensee's reports loaned to us (Nos. 1 to 15 inclusive) and also enclose reports not previously rendered to you for the quarters ending December 31, 1930 and March 31, 1931. These two (Nos. 16 and 17) together with the four reports next preceding (Nos. 12 to 15 inclusive) show the names of the customers supplied. Our report, therefore, lists the customers supplied only for the eleven quarters prior to September 30, 1929.

As stated in our report the sales records prior to January, 1929 are stated to have been destroyed, so that the figures for the first eight quarters have not been satisfactorily verified by us.

Yours very truly,

Encl.





Date	Sold to	Quantity	Type	Model	Amount
1929					
May 16	General Talking Pict. Corp.	6	A 41	#7	360.00
13	"	8	25A	#5	3,400.00
13	"	10	A 41	#7	600.00
10	"	10	A 41	#7	600.00
24	DeForest Phono. Film of Canada	2	A 41	#7	120.00
21	General Talking Pict. Corp.	5	A 41	#5	2,125.00
28	"	15	25A	#7	900.00
27	"	10	A 41	#5	4,250.00
24	DeForest Phono. Film of Canada	1	25A	#5	550.00
31	General Talking Pict. Corp.	8	25A	#7	430.00
1	"	7	A 41	#7	420.00
31	"	13	A 41	#7	780.00
	"	4	25A	#5	1,700.00
June 6	"	1	P.A. 47	#6	225.00
8	"	2	P.A. 47	#6	450.00
12	"	4	P.A. 47	#6	900.00
13	"	1	P.A. 47	#6	225.00
13	"	6	A 41	#7	360.00
11	"	11	25A	#5	4,675.00
11	"	2	P.A. 47	#6	450.00
14	"	12	A. 41	#7	720.00
19	"	8	A 41	#7	450.00
20	"	2	P.A. 47	#6	450.00
25	"	14	A 41	#7	840.00
24	"	1	25A	#5	425.00
27	"	6	A 41	#7	360.00
27	"	12	A 49	#8	480.00
28	DeForest Phono Film of Canada	5	25A 25 Cy.	#5	3,125.00
27	General Talking Pict. Corp.	3	25A	#5	1,275.00
25	"	5	P.A. 47	#6	1,125.00
29	"	3	A 49	#8	1,120.00
29	"	22	A 41	#7	1,320.00
1	DeForest Phono. Film of Canada	4	25A	#5	2,200.00
4	General Talking Pict. Corp.	4	A 41	#7	240.00

Pltff. Ex. 77, Item 6.

June 22, 1931.

✓  
American Transformer Company  
178 Emmet Street,  
Newark, New Jersey.

Gentlemen:-

Referring to my letter of June 10th  
it has just been noted that the word "prior" in the  
second line of the second paragraph should be "subse-  
quent".. Will you kindly make this change to correct  
an inadvertent error.

Yours very truly,

HGG:CC



1228

⑦ Lia. from folder ✓

December 30, 1931.

✓  
American Transformer Company,  
174-188 Essex Street,  
Newark, N.J.

Gentlemen:-

We have considered the summary as submitted of your sales for the fourth quarter of 1930 (October, November and December) under the power amplifier and supply license agreement. As stated in prior correspondence referring to summaries for other periods it is evident from a consideration of the names of your customers that practically all of such sales have been made to companies which intend to use the apparatus for purposes other than that for which it is licensed, namely, amateur reception, experimental reception and broadcast reception as such terms are defined in the license agreement.

We, therefore, are unwilling to accept your check of \$4,452.53, tendered to cover the royalty for this quarter and it is accordingly returned herewith. In lieu thereof please send us a check for royalties on sales made for licensed uses only. The list shown on the attached schedule "A" covers, we believe, the only items likely to have been sold for uses under such license.

For the same reason we are returning herewith your checks for \$1175.44, \$1180.93 and \$1356.69 tendered to cover the royalty for the first quarter, the second quarter and July of 1931. In lieu thereof we likewise request a check for royalties on sales made for licensed uses only and submit herewith schedules "B", "C" and "D" which we believe cover the only items likely to have been sold for uses under such license.

Yours very truly,

*W. H. Hoover*  
Patent Attorney.

WCC:CS  
Encs.

P.S. The checks mentioned above are returned herewith. The lists referred to will be mailed tomorrow.

## Schedule "A"

SALES MADE BY AMERICAN TRANSFORMER CORPORATIONDURING 4TH QUARTER OF 1930

<u>1930</u>	<u>Sold To</u>	<u>Quantity</u>	<u>Sales</u>	<u>Returns</u>
Oct: 3	Balkeit Company	1	85 00	
25	E. M. Zelony	1	351 00	
31	Hoovenir Corporation	1	80 00	
3	E. M. Zelony	1		540 00
3	" "	1		270 00
3	" "	1		540 00
Nov. 11	" "	1	87 75	
11	" "	1	87 75	
21	Linerophone Company	1	87 75	
13	M & H Sptg Goods	1		87 75
1	Hoovenir Corporation	1		80 00
1	C E Deane	1		300 00
Dec. 8	M. & H. Sptg Goods	1	78 75	
3	George Company	1	97 50	
18	Linerophone Company	1	97 50	
16	Asso. Rad. Buyers	1	72 00	
19	W.G. Preddy	1	87 75	
27	M. & H. Sptg Goods	1	82 00	
22	W.G. Preddy	1	87 75	
31	Amer. Tran. Sales Co.	1	155 00	
31	" " " "	1	109 20	
31	" " " "	1	163 80	
31	" " " "	1	155 00	
31	" " " "	1	109 20	
31	" " " "	1	163 80	
31	" " " "	1	176 80	
31	" " " "	1	124 80	
22	United Sound Eng.	1		72 00
22	Fox Elec. Manufacturing	1		87 75



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## Schedule "B"

SALES MADE BY AMERICAN TRANSFORMER CORPORATIONDURING FIRST QUARTER OF 1931

<u>1931</u>	<u>Sold To</u>	<u>Quantity</u>	<u>Sales</u>
Jan. 13	C.W. Mitchell	1	87 75
14	W.G. Preddy	1	87 75
16	W. Va. University	1	97 50
22	M. & H. Sptg Goods	1	81 00
14	Ad. Auriema	1	78 00
23	C.C. Langevin	1	87 75
29	M. & H. Sptg Goods	1	81 00
30	W.G. Preddy	1	87 75
28	Davenport E.	1	
30	Manus Elec.	2	
31	Ohio Music	1	
31	Lincophone Co.	1	
Feb. 6	W.G. Preddy	1	87 75
3	E. Markel	1	117 00
3	" "	2	210 00
10	" "	2	210 00
18	Lincophone Co.	1	97 50
21	Elec. Supply Corp.	1	87 75
18	Hughes - Peters	1	87 75
18	" "	1	72 00
25	Racon Elec.	1	83 25
20	E Markel	1	
24	M. & H. Sptg Goods	1	
Mar. 1	Ad. Auriema	1	78 00
1	Elec. Supply	1	87 75
6	Radio Supply	2	175 50
10	National Union Radio	1	80 00
18	W.G. Preddy	1	87 75
20	" " "	1	87 75
23	" " "	1	87 75
17	Hammarlund Roberts	1	87 75
31	Hughes - Peters	1	87 75
31	Amer. Trans. Sales	1	
31	" " "	1	
16	M. & H. Sptg Goods	1	
Jan. 9	Larus & Bro.	1	200 00
24	Kunsky Trendle	1	200 00
16	Suffolk Elec.	1	200 00
Mar. 2	N.J. Rad.	1	99 00
21	Universal Amp. Co.	1	412 50
21	" " "	1	450 00
21	" " "	1	138 75
21	" " "	1	195 00
25	Island Radio	1	180 00
25	" "	1	138 75
21	Universal Amp. Co.	1	87 75

1231

Schedule "B" Contid.

SALES MADE BY AMERICAN TRANSFORMER CORPORATIONDURING FIRST QUARTER OF 1931.

<u>1931</u>	<u>Sold To</u>	<u>Quantity</u>	<u>Sales</u>	<u>Returns</u>
Mar. 31	Radio Air. Serv.	1	225 00	
31	" " "	1	180 00	
31	" " "	1	138 75	
31	" " "	1	412 50	
31	" " "	1	87 75	
31	" " "	1	75 00	
31	" " "	1	252 00	



1232

ROYALTIES - JUNE 1931  
ROYALTIES - APRIL 1931

Schedule "C"

<u>1931</u>	<u>Sold To</u>	<u>Sales</u>
✓ Apr. 3	Cross Mfg. Co. - PA-86	97 50
3	Radio Air Serv. - A-36	150 00
3	" " " - P-32	108 75
3	" " " - PA-32	195 00
8	P.A. Boykin - PA-84	48 00
2	Silman Distrib. Co. - PA-86	87 75
10	J.K. Elderkin - PA-84	80 00
7	J.K. Elderkin - PA-86	97 50
10	Western Radio Eng. - P-77	292 50
7	Racon Elec Co. - PA-86	65 25
17	Elec. Supp. Corp. - PA-86	81 00
15	" " " - PA-86	87 75
15	" " " - A-89	81 00
15	" " " - A-89	40 50
16	Graybar Elec. - P-77	180 00
17	C.M. Bowman - PA-86	108 00
20	Radio Air Serv. - 2 Spec. "AP Amp. \$46 Ea.	92 00
20	Elec. Supp. Corp. - PA-86	87 75
25	Dooleyphone Co. - PA-86	97 50
25	" " " - PA-86	80 00
24	American Tel & Tel. - PA-86	105 00
27	Steinman, H. - PA-86	87 75
27	" - 101 Speaker Rect.	25 20
27	Radio Air Service - A-86	72 00
30	Elec. Supp. - PA-86	87 75
30	Officer in Charge - PA83 2 @ \$87 Ea	174 00
25	T.M. Zelony - A-80	202 50
24	H. Steinman - P-78	42 75
24	Radio Air Service - PA-84	550 00
24	" " " - 2 - 2AP @ \$46 Ea.	92 00
30	H. Steinmann - PA-86	87 75
30	" " " - 101 @ \$25.20 Ea.	50 40

## LESS CREDITS

14	E. Martell - A-72	105 00
14	" " " - 2 - 85 @ \$108 Ea.	210 00
15	Ad. Auricums - P-83	49 88
	" " " - PA-84	55 04
	" " " - PA-86	61 92
	" " " - PA-86	66 08
	Wilmington Elec. - P-51	300 00

77/8

Schedule "C" Contd.

ROYALTIES - MAY 1931.

<u>1931</u>	<u>Sold To</u>	<u>Sales</u>
May 1	Independent Radio	97 50
2	Mr. Knowles - PA-84 S	80 00
4	Amusement Supp. - A-67	180 00
	" " - P-63	138 75
1	Radio Air Serv. - A-67B	140 40
	" " " - P-63B	108 22
2	Bell Tel. Lab. - P-106	160 00
7	C.C. Langevin - P-108	85 00
11	W.G. Preddy - PA-86	87 50
14	Elec. Supply Co. - a PA-86 @ \$87.75 Ea.	175 50
16	R.V. Terry - PA-86	97 50
14	Radio Air Serv. - PA-86	87 75
	Ad. Aurisma - PA-86	78 00
20	Cross Mfg. - PA-86	97 50
	C.C. Langevin - PA-86	87 75
21	E.M. Zelony - PA-86	87 75
20	Amusement Supp. - A-67	180 00
	" " - P-63	138 75
18	Electro Sound Prod. - PA-84	80 00
26	Wireless Egert - PA-84	72 00
27	Emmanuel Miss. Coll - PA-86	117 00
	" " " - A-88	96 00
29	Bay Smith Co. - PA-86	97 50
 CREDITS:		
13	T.V. Gould-PA-61	275 00
23	Good-all Elec. - A - A-53 @ \$88 Ea.	156 00
29	Elec. Supp. Co. - PA-86	87 75

171.9



1231

Schedule "C" Contd.

ROYALTIES - JUNE 1931

<u>1931</u>	<u>Sold To</u>	<u>Sales</u>
June 5	Electro-Phone Corp. - PA-85	87 75
3	Sun Radio Co. - PA-83	65 25
	Elec. Supply Corp. - A-89	40 50
	" " - A-89	40 50
	" " - PA-85	81 00
	L. Deane - PA-85	87 75
5	Universal Amplifying Co. - PA-84	87 75
9	L.E. Wyant - PA-85	97 50
10	Ad. Amriana - PA-85	78 00
9	H.H. Steinman - PA-85	87 75
10	E. Markell - RABO @ \$54. Ea.	108 00
8	H.H. Steinman - P-101	42 00
5	Hughes-Peters Elec. P-101	25 20
13	Simplinus - A-89	45 00
	" - PA-85	90 00
11	Elec. Serv. Supp. - PA-84	80 00
16	Simplinus, Inc. - PA-85	90 00
17	George Rogers - PA-85	87 75
16	H.H. Steinman - PA-84	72 00
	" " - P-101	25 20
20	Simplinus - A-89	67 50
	" - PA-85	90 00
16	C.C. Langevin - PA-85	81 00
17	Elec. Serv. Supp. - A-88	80 00
23	L.E. Wyant - A-88	80 00
23	Ad. Amriana - A-88	84 00
20	E. Markell - A-89	45 00
	" " - A-88	97 50
22	S.L. Baraf - 2 PA-85 @ \$87.75 Ea	175 50
24	Electro-Phone Corp. - PA-84	72 00
23	Banier Mfg. Co. - PA-85	87 75
25	Universal Amplifying - PA-85	87 75
26	Electro Sound Products - PA-84	72 00
23	Elec. & Radio Distrib Co. - A-85	150 00
	" " " " - P-88	108 75
	" " " " - PA-89	195 00
	" " " " - A-80	225 00
	" " " " - P-102	117 00
<b>CREDITS</b>		
12	Radio Air Service - PA-84	550 00
18	Markell To correct invoice	(18 00)
24	H.H. Steinman - To correct invoice	(16.80)

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Schedule "D"

ROYALTIES FOR JULY 1931

<u>1931</u>	<u>Sold To</u>	<u>Sales</u>
July 10	Ad. Auriema - 1 PA-83 Amplifier	58 00
9	Pacific Gas & Elec. Co. 1 PA-83 Ampli.	87 75
9	Eugene Gwile 1 PA-83 Amp.	81 00
14	Brown & Rhine 1 PA-83 Amp.	97 50
3	Dracclair Amusement Co. 1 PA-83 Amp.	97 50
15	Radio & Elec. Distributors 1 PA-83 Amp.	87 75
22	" " " 1 A-83	80 00
20	Wenger-Brill Co. 1 PA-83 Amp.	87 75
24	Renier Mfg. Co. 1 PA-83 Amp.	87 75
24	D'Elia Elec Co. 1 PA-83 Amp.	81 00
	" " " 1 A-83 Amp.	72 00
27	M. & H. Sportingsheds 1 PA-83 Amp.	77 89
28	W.G. Preddy 1 PA-83 Amp.	87 75
31	C. Alvord 1 PA-83 Amp.	87 00

LESS CREDITS:

22	Western Rad. Eng. P-77 billed 4/10	
	\$292.50 should be \$200 - \$92.50	
29	Radio & Elec. Dis. 1-A-83 Amp.	80.00
31	Elec-tro-fone Corp. -----	
	1-PAS3	87.75

7/21



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Pltff. Ex. 77, Item 8.

January 7, 1932.

American Transformer Company,  
178 Emmet Street,  
Newark, N.J.

Attention Mr. Chas. F. Loughhead.

Gentlemen:-

We acknowledge receipt of your letter of  
January 5th and the accompanying check for \$1,072.24  
covering royalties in connection with the power  
amplifier and supply license.

Yours very truly,

*W. B. Hoover*  
Patent Attorney.

HGG:CC

cc- E C Anderson

RECEIVED

JAN 9 - 1932

License Division

1237

Pltff. Ex. 77, Item 9.

**RADIO CORPORATION OF AMERICA**

No. 76070

**NATIONAL BANK OF COMMERCE 1-23**  
NEW YORK

December 9, 1930

**EXAGINE 14534 @ 39 CTS**

*Frank E. Doyle*

*W. H. Hoffman*

American Transformer Corporation

Pay to the order of

RECEIVED PAYMENT  
JUL 25 1931  
1-23 GUARANTY TRUST CO. NEW YORK  
BANK OF COMMERCE NEW YORK  
NATL BANK OF COMMERCE NEW YORK  
TRANSISTED



194000 CORPORATION OF AMERICA

NATIONAL BANK OF COMMERCE 1-25  
NEW YORK

EXACTLY 6410 23 25 CTS

June 4, 1931

No. 78896

\$6410.25

American Transformer Company

*Frank C. ...*

*R. ...*

RECEIVED PAYMENT  
JUN 4 1931  
23 CENTS  
BANK OF COMMERCE IN NEW YORK  
NATL. BANK OF COMMERCE IN NEW YORK  
TRANSIT DEPT.

THE GROUP  
A TRUST COMPANY  
OF NEW YORK  
NEW YORK, N.Y.

250

Case 1 x

Associated  
Forfeited.

DIV. 16

1914

(EXTS BOOK) 214-26

NUMBER (Series of 1900).

841567

PATENT No.

Harold Le Forest Assoc.  
Admrs to Western Electric Company  
New York, N.Y., a corp. of N.Y.

East Orange

County of

State of

Residence

Auditors

New Jersey

ORIGINAL

RECEIVED

Petition May 28, 1914  
Fees doct 1, 1914  
Specification 1, 1914  
Drawing 1, 1914  
Photo Copy June 4, 1914  
First Fee Cash 15 May 28, 1914  
" " Oct 1, 1914  
App. Fee complete May 28, 1914

This application referred  
to in Patent No. 1354934  
Do not destroy. (See order  
No. 3166, 400 O.G. 1)

Examined and Passed for Issue Oct. 28, 1914

A.D. Backus Exp. Dir. 16  
Notice of Allowance Dec. 2, 1914  
First Fee Cash 191  
" " Oct 191

Exp. Dir.

Attorney De Witt C. Tanner, 111 West Street  
Catharine 192 Broadway New York City  
Solicitor John J. Roberts, 111 West Street  
920 Broadway New York City

(No. of Claims Allowed 2) Title as Allowed

(1914, 11.1)

Questions

100 350-27



21

22

23

24

TO ALL WHOM IT MAY CONCERN:

25

Be it known, that I, HAROLD DeFOREST ARNOLD,

26

a citizen of the United States, residing at East Orange,

27

in the County of Essex and State of New Jersey, have

28

invented certain new and useful improvements in

29

Audions, of which the following is a full, clear,

30

concise and exact description.

31

This invention relates to

32

thermionic repeaters, such as the audion,

-1- 78/2

1 and its object is to provide a structure of increased efficiency  
2 and of either low-current and high-voltage or high-current  
3 and low-voltage output, as may be desired.

4 It has been discovered that by arranging the input/  
5 electrode or grid as closely as possible to the cathode or filament  
6 the efficiency of the audion is greatly increased. It has  
7 also been discovered that, by properly adjusting the position  
8 of the output electrode or plate with respect to the filament,  
9 the output current and voltage of the audion can be controlled.

10 It has also been discovered that the amount of obstruction  
11 the input electrode presents between the output electrode  
12 and the filament is also a factor in controlling the output  
13 current of the audion. In accordance with this invention,  
14 therefore, it is possible to improve the efficiency of the  
15 usual high-voltage output type of audion and to provide an  
16 audion distinctly new in type, having a high-current and  
17 low-voltage output.

18 The several features of this invention may be more  
19 readily understood by reference to the accompanying drawings  
20 in which,-

21 Fig. 1 is a perspective view of an improved audion  
22 having a low-current and high-voltage output;

23 Fig. 2 is a top plan view illustrating the relative  
24 position of the input and output electrodes and the filament  
25 shown in Fig. 1;

26 Fig. 3 is a fragmentary perspective view of the new  
27 type of audion having a high-current and low-voltage output;

28 Fig. 4 is a top plan view illustrating the relative  
29 position of the input and output electrodes and the filament  
30 shown in Fig. 3; and

31 Figs. 5 and 6 are views corresponding to Figs. 3  
32 and 4, respectively, of a modified structure of the afore-



mentioned new type of audion.

Like reference characters refer to like parts throughout the several views.

Referring first to Figs. 1 and 2, the input electrode or grid 1 is placed as closely as possible to the filament 2. It has been found that the closer these two elements are placed together, the stronger the electric field and the more efficient the action of the audion. In practice it has been found that when the two elements are placed side by side or so closely placed together that a mere oxidizing coating on the one or the other is relied upon to electrically separate the same, the most efficient action is secured.

It has furthermore been discovered that the distance between the filament and the output electrode or plate 3 is an important factor in the voltage output of the audion. Within working limits, the farther the plate is located from the filament, the higher becomes the voltage. Another factor entering into the output voltage is the structure of the input electrode or grid 1, the more obstruction the electrode 1 offers between the filament and the output electrode the higher the output voltage. In Fig. 1, the input electrode 1 is shown as consisting of a grid having a very fine mesh interposed between the filament 2 and the plate 3, such being the preferred construction in this high-voltage output type of audion.

In the aforementioned high-voltage output type of audion illustrated in Figs. 1 and 2, in order to secure the most efficient structure, the input electrode or grid 1 should be as near as possible to the filament, the output electrode or plate should be distant from the filament, and the input electrode or grid should present a finely divided or meshed

1 surface between the filament and plate. The filament need  
 2 not present a very large active area. An audion having  
 3 such structure will give a high degree of amplification,  
 4 the output thereof being a low current with a high voltage.

5 As contrasted with the improved audion of the  
 6 usual high-voltage output type shown in Figs. 1 and 2, is  
 7 the new high-current output audion illustrated in Figs. 3  
 8 and 4 and Figs. 5 and 6, respectively. In such new type,  
 9 the input electrode or grid 1<sup>a</sup> is placed as close as possible  
 10 to the filament 2<sup>a</sup> in order to secure the greatest efficiency,  
 11 in this respect the high-current output audion resembling the  
 12 improved high-voltage output audion hereinbefore described.  
 13 In this high-current output type, however, the plate 3<sup>a</sup> is  
 14 placed as close to the filament as is conveniently possible,  
 15 since the effect of advancing the plate towards the filament  
 16 is to lower the output voltage of the audion. As herein-  
 17 before stated, another factor controlling the output voltage  
 18 is the input electrode or grid 1<sup>a</sup>, which should offer minimum  
 19 obstruction between the plate and filament. In Figs. 3 and  
 20 4, the input electrode is shown as a grid 1<sup>a</sup> having a very  
 21 coarse mesh.

22 In Figs. 5 and 6, there is shown another modifica-  
 23 tion of the ~~low-voltage output audion~~ <sup>high-current</sup> ~~certain of the specific~~  
 24 ~~details thereof being the invention of another and forming~~  
 25 ~~the subject-matter of a separate application.~~ In said  
 26 Figs. 5 and 6, the input electrode is in the form of a wire  
 27 1<sup>a</sup> bent back at its middle. In effect, therefore, the in-  
 28 put electrode consists of two wires joined together. The  
 29 filament 2<sup>a</sup> is entwined about the input electrode and is  
 30 insulated therefrom by the <sup>a tube of</sup> insulating material 4<sup>a</sup>. The  
 31 output mode consists of two plates 3<sup>a</sup>, 3<sup>b</sup> arranged upon  
 32 opposite sides of the filament close thereto. It will be



1 noted that the input electrode is not located between the  
2 filament and plate, such not being necessary for efficient  
3 action in this high-current output type of audion.

4 Referring to the audion structures illustrated  
5 in Figs. 3 and 4 and Figs. 5 and 6, respectively, it will  
6 be noted that the greatest efficiency is attained by placing  
7 the input electrode as near as possible to the filament, by  
8 placing the plate near to the filament, by providing a large  
9 filament area, and by so constructing and locating the in-  
10 put electrode that it presents the least possible obstruction  
11 between the filament and output electrode or plate. It has  
12 been found that in accordance with this invention, an audion  
13 may be constructed which will ~~step down~~ the input voltage to  
14 ~~one-third of its original value~~, that is, the audion will have  
15 an output of high current and low voltage. Such new type  
16 of audion, because of its low output impedance, as low, for  
17 example, as 500 ohms, can be worked efficiently into a line  
18 of like impedance.

*Invent A*

19 A combination of the two types of audions above  
20 described, to provide a very efficient amplifying means  
21 which can be directly connected in a line of low impedance,  
22 forms the subject-matter of a depending application of even  
23 date herewith. *in my name, Ser. No. 841,542 filed*

24 By thermionic repeater is meant a repeater  
25 depending for its operation upon current discharge from a  
26 heated cathode. The invention is illustrated and claimed  
27 herein as applied to the audion which is believed to be the  
28 best type of thermionic repeater. In its broadest aspect,  
29 however, the invention is not limited to the particular  
30 structure herein illustrated but may be found useful in  
31 modified forms or types of thermionic repeaters.

32

What is claimed is:

1. An audion having its input electrode in immediate proximity to its filament but out of electrical contact therewith.
2. An audion having its input electrode and filament arranged as close together as possible and separated by insulating material.
3. An audion comprising an input electrode, an output electrode and a filament, said output electrode being located so close to the filament as to step down the output voltage of said audion.
4. An audion comprising an input electrode, an output electrode and a filament, said input electrode being located as close as possible to said filament but out of electrical contact therewith, and said output electrode being very slightly spaced apart from said filament, thereby conducing to an amplification of current in the output of said audion.
5. An audion comprising an input electrode, an output electrode and a filament, said input electrode being in immediate proximity to said filament but out of electrical contact therewith, said filament having a large area, and said output electrode being so slightly spaced apart from said filament as to conduce to an amplification of current in the output of said audion.
6. An audion comprising an input electrode, an output electrode and a filament, said output electrode being located so close to the filament as to step down the output voltage of said audion, and said input electrode offering minimum obstruction between the output electrode and filament.
7. An audion comprising an input electrode, an output electrode and a filament, said input electrode offering



minimum obstruction between said output electrode and filament and being located in immediate proximity to said filament but out of electrical contact therewith, and said output electrode being very slightly spaced apart from said filament.

8. An audion comprising an input electrode consisting of a grid having a very coarse mesh, an output electrode and a filament, said grid being located as close as possible to said filament but out of electrical contact therewith, and said input electrode being located so near to said filament as to conduce to an amplification of current in the output of the audion.

9. An audion having its input electrode and filament arranged in close proximity and separated by a film of insulating material.

10. An audion having an input electrode and filament, and a film of insulating material carried by one of said elements and with which the other element contacts.

11. An audion having an input electrode and a filament, and an interposed separating film of non-conducting material in contact with both.

CAF-10

In Witness Whereof, I

hereunto subscribe my

name this 25 day of May A. D. 1914

WITNESSES

Harold DeForest Arnold ✓

E. Allen

H. L. Jell

State of New York

COUNTY OF New York

ss.

HAROLD DeFOREST ARNOLD

\_\_\_\_\_, the above named petitioner,  
being duly sworn, deposes and says that he is a \_\_\_\_\_ citizen  
of the United States, and resident of East Orange in the  
County of Essex and State of New Jersey  
and that he \_\_\_\_\_ verily believes himself \_\_\_\_\_ to be the  
original, first, and sole \_\_\_\_\_ inventor of the improvement in \_\_\_\_\_

And I deem

described and claimed in the annexed specification; that he \_\_\_\_\_ does not  
know and does not believe that the same was ever known or used before  
his \_\_\_\_\_ invention or discovery thereof; or patented or described in any  
printed publication in the United States of America or any foreign country  
before his \_\_\_\_\_ invention or discovery thereof or more than two years prior  
to this application; or in public use or on sale in the United States for more  
than two years prior to this application; and that no application for foreign  
patent has been made by him \_\_\_\_\_ or his \_\_\_\_\_ legal representatives or  
assigns in any foreign country.

Harold DeForest Arnold ✓

Sworn to and subscribed before me

this 25 day of May 1914

Ella Allen

Notary Public.



1218

NOV 18 1909 309 118  
U. S. DEPARTMENT OF COMMERCE  
BUREAU OF PATENTS  
WASHINGTON, D. C.

DEPARTMENT  
UNITED STATES  
WA

John G. Roberts,  
463 West St.,  
New York, N. Y.

Please find below a communication from  
H. D. Arnold, Serial No. 841  
Audions.

Thomas Edison

This case has been examined  
The following references

de Forest, 879,5  
Stone et al, 884,1  
"The Wireless Telegraph"  
second edition, 1907  
Co., 215 Fulton St

The use of the term out  
and claims is criticised here  
action at the audion and in  
14, page 5, that the audion  
to one-third of its original  
copper circuit of an audion  
battery in the receiver circuit  
de Forest and Stone, cited.  
to affect the passage of electric  
copper circuit and in that way  
in the receiver circuit. It  
apparently is the potential

Page No. 2

RECEIVED  
OFFICE OF THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.  
AUG 17 1914

DEPARTMENT OF THE INTERIOR

PATENT OFFICE

WASHINGTON

AUGUST 17, 1914.

U. S. PATENT OFFICE  
AUG 17 1914  
MAILED

EXAMINED in charge of the application of  
No. 1,117,167, Filed May 28, 1914, for

*[Signature]*  
Charles F. Smith, Patent

and considered.

are made of record:

Feb. 10, 1908, 250-27-X

Apr. 7, 1908, " -27.

U. S. No. 2, by H. Gernsback,

published by Modern Publishing

Co., N. Y. City.

It is stated in the specification

that it implies a transformer

as it is stated in lines 13 and

will step down the input voltage

value." The voltage of the re-

thought to be governed by the

U. S. No. 2, as e. g. the battery B in

the only effect of the audion is

transacross the gap in the re-

set up variations of current

is meant by out-put voltage

or between the filament and plate,



841,537,-----3.

or out-put terminals.

✓ The specification and claims  
special attention being directed  
lines 13 and 14, page 5, and line

✓ The sentence beginning in line  
erased since another's invention  
has become a patent.

The description of Figs. 5 and  
page 4 is thought to be in error  
and 2b as the hot wire filament:  
reversed.

✓ The reference to the copending  
paragraph on page 5, should be ind  
if not, the reference should be co

Claims 1 to 9 are rejected on  
attention being particularly calle  
"Wireless Telephone" in which an su  
filament and plate spaced 3 millia  
midway there between. Such terms  
"as close as possible" are indefin  
distinguish from the art cited.

0 The expression "amplification  
4, 5 and 6, is objected to. The c  
is generated by the battery in sec  
varies this current. The expressio  
"changes (or variations)" is though

Claim 9 does not distinguish  
an air gap between the filament and  
of oxid on the filament or grid.

Claims 10 and 11 are allowed

CSG

ac

1219

should be corrected accordingly  
to lines 17 and 18, page 3.

, claims 3 and 4.

22, page 4, should be  
only be referred to after it

6 in the last paragraph on  
describing 13 as the grid  
these elements are evidently

application in the second  
identified, if filed by applicant;  
replied.

either of the references cited,

to pages 64 and 65 of "The  
ion is described having the  
bars apart and the grid about  
"immediate proximity" and  
be and vague and fail to

of current" in line 6, claims  
rent in the receiver circuit  
circuit and the audion merely  
"amplification of current  
to be accurate.

on the references which have  
grid in addition to the film

*Sidney F. Smith.*  
Examiner, Div. 16.



1250



PAPER NO. 3  
AMENDMENT *a*

UNITED STATES PATENT OFFICE  
Division 16 - Room 309.

In re application of  
Harold DeForest Arnold  
Serial No. 841,567.  
Filed May 28, 1914.

Andions.

COMMISSIONER OF PATENTS.

Washington, D.C.

PATENT OFFICE  
SEP 22 1914  
DIV. 16 FILED

Sir:

In response to Office action dated August 17, 1914,  
please amend the above entitled application as follows:

✓ Page 4, lines 24 and 25, erase "being" down to  
"application" and substitute --not being the invention of this  
applicant--; line 30, erase "the" (first occurrence) and substi-  
tute --a tube of--.

Page 5, lines 13 and 14, erase "step down" to  
"original value" and substitute ~~develop~~ amplified energy at  
a voltage one-third of the voltage of the input energy--

✓ Erase all of the claims and substitute therefor the  
following:

*Q<sup>1</sup>  
Per E*

~~1. A thermionic repeater having its input  
electrode in immediate proximity to its cathode but  
out of electrical contact therewith.~~

*Q<sup>2</sup>  
Sub. C.  
Per E*

~~2. A thermionic repeater having its input  
electrode and cathode arranged as close together  
as possible without contacting.~~

~~3. A thermionic repeater having its output  
electrode arranged so close to its cathode as to  
develop output energy at a voltage lower than the  
voltage of the input energy.~~

~~4. A thermionic repeater having its output  
electrode arranged so close to its cathode that the~~

space impedance between said elements has an operating value not exceeding approximately 500 ohms.

*Sub C.2*

~~B. A thermionic repeater having its input electrode in immediate proximity to its cathode but out of electrical contact therewith, and its output electrode arranged so close to said cathode as to develop amplified energy at high current and low voltage as compared with the current and voltage of the input energy.~~

REMARKS

Claims 10 and 11 which had been allowed have been erased because they describe a structure that is not the intention of this applicant. They were included in this application by this inadvertence and are now inserted, in modified form, in another application of the same assignee.

The description of Figs. 5 and 6 in the last paragraph of page 4 is believed not in error. In this embodiment of applicant's invention the input electrode is the wire 1<sup>a</sup> within the tube 4, and the heated cathode is a filament in the form of the spiral wire 2<sup>b</sup> entwined about the tube, as stated in the specification.

The objection to the expressions amplification of current, output and input voltage and current, etc., is believed not well taken. These expressions are commonly used in describing the characteristics of audions and other forms of repeaters, and no better expressions are known which may be substituted therefor. The action of the audion and particularly of the one described in this application is in fact similar, or analogous at least, to that of a transformer. Of course the output energy is not derived so directly from the input energy as in a transformer, but nevertheless the input energy has certain voltage and current characteristics and the output



energy may have certain other voltage and current characteristics, so that it seems proper to refer to the action as amplification of current or amplification of voltage, as well as amplification of energy. It is true to a certain extent, as stated in the Office letter, that the voltage of the receiver (output) circuit of an audion is governed by the battery in the receiver (output) circuit, but it is not usual and certainly misleading to speak of the output voltage as being a function of the voltage of the battery in the output circuit. Rather, the output voltage is the voltage of the alternating or fluctuating current impressed upon the circuit of that battery. That is to say, the only effective output voltage is the alternating current potential developed between the filament and plate. This may be of, and ordinarily has, a very different value from the voltage of the battery itself.

It is also true in a sense, as stated in the Office letter, that the only effect of the audion is to affect the passage of electrons across the gap of the receiver (output) circuit, and in that way to set up variations of current in the receiver (output) circuit. It is, however, also true that this phenomenon manifests itself as a superimposed alternating potential across the gap and a fluctuation of current in the circuit. If we consider the output circuit as connected inductively with an outgoing line, we can see clearly enough that the only energy available in the outgoing line is that due to this alternating potential and alternating current, developed in the output circuit by the input energy acting through the input electrode.

The suggestion that the expression "amplification of current changes or variations" is thought to be more accurate than "amplification of current" is not believed to be well taken. It is thought to be meaningless to refer to the amplification of changes of current. The audion as well as other forms of

amplifiers, deals with real quantities. It is electrical energy, the product of current and voltage, which is amplified.

The substituted claims are in the best form that applicant knows of to express his invention. It is no doubt true that the terms "immediate proximity" and "as close as possible" would be objectionable if more definite expressions could be used. In respect to the present invention, however, there does not appear to be any other language adequately to describe it. The invention is based upon a discovery of very great importance, i.e., the closer the input electrode and cathode are placed together, the more efficient is the action of the audion. Higher efficiency in the audion means a higher amplifying ratio, and is greatly to be desired. Heretofore, as in the references cited, the input electrode or grid was simply arranged approximately midway between the cathode and the output electrode or anode. There was no effort to arrange the input electrode in immediate proximity, or as close as possible, to the cathode, and no one before applicant so far as known had any idea that this would produce beneficial results. It is persuasive of the great merit of applicant's invention that certain forms of audions have been developed since applicant's invention was made, and on the basis thereof wherein to secure the maximum efficiency, the input electrode has been placed as close as approximately .001 of a millimeter from the cathode without electrically contacting with it. Applicant shows two embodiments of the invention in which the input electrode and filament are arranged adjacent each other in space and maintained by careful construction and rigid mounting as close together as possible, but out of electrical contact with each other. He has also shown in Figs 5 and 6 a modified form of the invention in which a small tube of insulation is placed about the input electrode, the filament being wound around the tube. By making the walls of this tube of small dimensions, the filament may be maintained exceedingly close to the input electrode.



Particular emphasis seems to be given in the Office action to the Wireless Telephone, wherein is described an audion having a small platinum plate fastened approximately 3 millimeters from the filament, and a grid placed nearly midway between the two. A very crude form of the audion is illustrated and there seems to be no means in this device for insuring that these elements shall not come in contact with each other during use. It is not stated in this book that there is any advantage at all in placing the elements close together, and it is not believed that there was meant to be described in this book an audion having a very high efficiency by reason of close proximity of the elements, one to the other. Furthermore, the distance apart of the elements is far too great, even when the 3 millimeters distance between the plate and filament is divided by 2 and lessened by the thickness of the grid wire, to produce the very efficient results secured in audions made according to applicant's invention wherein the input electrode is placed as close as possible or in immediate proximity to the filament. It is not believed that such a crude construction as described in this publication, which is admitted to be a device "yet in an undeveloped stage", should be considered as anticipating the highly developed structures embodying applicant's invention and based on such an important and far reaching discovery.

The pertinency of the other two references cited is not at all apparent and with the revised claims the application is believed to be in condition for allowance.

In view of the close relationship of the present application to other applications relating to like subject matter and assigned to the same assignee, it is requested that this application be made special and acted upon as soon as possible.

Respectfully,

H. B. AMFIELD,

440 West Street,  
New York, September 12, 1921.

1255

MAIL ROOM  
OCT 10 1914  
UNITED STATES PATENT OFFICE  
Division 10, Room 309

PAPER NO. 4

AMENDMENT 8

In re application of  
Harold DeForest Arnold  
Serial No. 841,867  
Filed May 28, 1914

Audions

RECEIVED

OCT 17 1914

DIV. 10, R. 309

COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

Please further amend this application as follows:

Page 4, line 10, after "efficiency" insert a comma;  
same page, line 23, change "low-voltage" to --high-current--;  
lines 23 and 24, place a period after "audion" and cancel  
the remainder of the sentence; same page, line 30, after  
"4" place a comma and insert:

--an arrangement which is not the invention of  
this applicant, but is described and claimed  
in a pending application in the name of  
Alexander Nelson Nicolson, Ser. No. 883,800  
filed September 25, 1914 and assigned to the  
same assignee as the present application.--

Page 8, line 22, after "application" insert --in my  
name, Ser. No. 841,868 filed--.

Respectfully,

HAROLD DEFOREST ARNOLD.

by

*Attorney*  
Attorney

493 West Street,

New York, October 7, 1914.

11-20

78/7

B1  
Per E



1256

Div. 16 Room 109

2-200

Paper No. 5

*Address only*  
The Commissioner of Patents,  
Washington, D. C.,  
and not any official by name.

FK

All communications respecting the  
application should give the serial number,  
date of filing, title, inventor, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

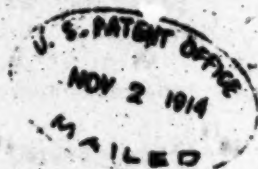
WASHINGTON

Nov. 2, 1914.

John G. Roberts.

442 West St.,

New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of

Harold De Forest Arnold, S. N. 841,847, filed May 28, 1914.

*Thomas Ewing*  
Commissioner of Patents

In response to amendment filed October 10, 1914.

Applicant's argument has been carefully considered, but the examiner is not convinced that the broad claims submitted in any way distinguish from the prior art as exemplified by the references of record.

The terms "immediate proximity" and "as close together as possible" are merely relative and wholly insufficient to distinguish from the references. In the section described in the pamphlet "The Wireless Telephone" the cathode and the grid are only one and one-half millimeter wide one-half the thickness of the grid apart. This is obviously an extremely small space and as applicant states in his argument they may be so close together as to at times come in contact. If so, they are clearly as close together as it would be possible to place them, but on the other hand, it is held that the structure as disclosed is clearly operative and that it will anticipate any claim that will read upon it. Applicant further states in his remarks that the distance in these references is far too great, if this is true limitations should be put in the claims so that they will distinguish from the references by structure rather than by vague and indefinite terms.

T/s

The claims are each accordingly rejected.

Claim 3 is further rejected as being inaccurate and misleading in reciting that the output electrode and cathode are arranged so close together as to develop output energy at a low voltage. Nowhere in the specification is it stated that merely placing the grid and cathode close together will have any effect on the output voltage. On the other hand, the specification states that the output voltage is determined by the distance between the output electrode and the cathode and by the amount of obstruction offered by the grid. It appears therefore that the small distance between the cathode has little, if any, effect on the output voltage, and claim 3 is accordingly misleading and misleading.

all

Wm A. Kinnear

Examiner Div. 16.

S



1258

MAIL ROOM  
FEB 5 1915  
U. S. PATENT OFFICE

PAPER NO. 6  
AMENDMENT C

U. S. PATENT OFFICE  
Division 16 - Room 109

In re. application  
Harold DeForest Arnold,  
Serial No. 841, 847,  
Filed May 20, 1914.

Amendments.

PATENT OFFICE

FEB 5 1915

ON 16 FILED

COMMISSIONER OF PATENTS:

Washington, D.C.

Sir:

In response to the Office action of November 2, 1914,  
please amend the above entitled application as follows:

Cancel claims 1 and 2 and substitute therefor the following:

1. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode in immediate proximity to said cathode but out of electrical contact therewith and closer to said cathode than to said output electrode.

2. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode as close as possible to said cathode without contacting therewith and closer to said cathode than to said output electrode.--

Cancel claim 3 and substitute therefor the following

3. A thermionic repeater having its output electrode arranged as close to its cathode as to

develop output energy at a voltage lower than the voltage of the input energy and having its input electrode arranged closer to said cathode than to said output electrode.

6. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said output electrode and said cathode being so spaced apart and the amount of obstruction offered by said input electrode being such as to develop output energy at a voltage differing from the voltage of the input energy by a predetermined ratio.

7. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said output electrode and said cathode being so spaced apart and the amount of obstruction offered by said input electrode being such as to develop output energy at a predetermined voltage lower than the voltage of the input energy.

8. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said input electrode being arranged much closer to said cathode than to said output electrode, and said output electrode and said cathode being so spaced apart and the amount of obstruction offered by said input electrode being such as to develop output energy at a voltage differing from the voltage of the input energy by a predetermined ratio.--

#### REMARKS.

A reconsideration of claims 3 and 8 without amendment is respectfully requested. From the last paragraph of the Office action, it would seem that the Examiner misread these two claims, since reference is made by him to "placing the grid and cathode close together". Such an arrangement of the grid and cathode



is not set forth in claims 3 and 4, but said claims are directed to such an arrangement of the output electrode or plate and the heated cathode as will develop a voltage lower than the voltage of the input energy.

A feature of consideration on all the claims is respectfully requested. As pointed out in the specification, there are three factors involved in applicant's present invention. One is the placing of the grid or input electrode as close as possible to the cathode or heated filament. This is desirable as giving the best results whether embodied in the one or the other of the two novel types of thermionic repeaters disclosed in the present application. The output voltage varies directly with the distance between the output electrode or plate and the heated cathode, this being the most important factor for determining the output voltage. The output voltage also varies inversely as the distance between the wires of the grid, that is, the less obstruction the grid offers, the lower the output voltage. Therefore, for the production of the best possible thermionic repeater of either of the new types disclosed in the specification, it is desirable that all three of the above mentioned factors be taken into consideration, though satisfactory results can be obtained merely from taking into consideration any one or more of such factors. The claims are not believed to fully distinguish from the references of record. For example, in the section described in "The Wireless Telephone" the grid is located midway between the heated filament and the plate, which is the same relative arrangement of the parts as are shown in the Stone and DeForest patents, cited. In the case of applicant's invention, as set forth in the claims, there is a different relative arrangement designed to produce distinctively different results. As set forth, for example, in claim 1, the grid is much closer to the heated cathode than it is to the plate. Either one or more of the distinguishing features of applicant's invention are set forth

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in each of the claims, which claims now fully distinguish from the  
audion structure described in "The Wireless Telephone" and in the  
DeForest and Stone patents of record.

Respectfully,

HAROLD DEFOREST ARNOLD

By A. C. Munnell

Attorney

463 West Street,

New York Feb 3, 1926.

RECEIVED



Div. 16 Room 109

The Commissioner of Patents,  
Washington, D. C.,  
and not any official by name.

S-200

Paper No. 7

All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

Feb. 16, 1915.

Mr. John G. Maharsa,

402 West Street,

New York, N. Y.

PATENT OFFICE  
FEB 16 1915

MAILED

Please find below a communication from the EXAMINER in charge of the application of

N. G. Arnold, S. No. 841,557, filed May 28, 1914.

Audions.

Thomas Ewing  
Commissioner of Patents

This action is in response to amendment filed Feb.

4, 1915.

The following references are added to the record:

Pierce 1,112,655, Oct. 6, 1914, 250-27, X,  
Schloemilch et al, 1,067,892, Feb. 17, 1914, " " "

Attention is directed to the specification of Pierce, line 16, et seq., page 3, in which it is stated that the voltage of the batteries in the out-put circuit of audions depends, among other things, upon the distance between the cathodes and anodes and screens in the vessel and also upon the size of the mesh of the screens. A similar statement is made in the patent to Schloemilch in the sentence beginning in line 97, page 1. It therefore appears that the potential drop between the cathode and anode of an audion depends upon the voltage of the battery in the out-put circuit and that it has been known prior to the present application that this potential drop is smaller the smaller the distance between the two terminals. Claims 3, 4, 6 and 7 are accordingly rejected as either of the references above cited. Since it is well known that the voltage of

841,567 -- 2.

the out-put circuit varies with the distance between the out-put terminals, there would be no invention broadly in making this distance so small that the out-put voltage would be less than the in-put voltage or that the space impedance between the two terminals would be less than five hundred ohms.

Claim 6 and 7 are further rejected as being functional and indefinite.

Claim 8, line 8, the last word is misspelled.

Claims 1, 2, 5 and 8 are allowed

*Wm A. Kinnear*  
Examiner, Division XVI.

AS



1261

PAPER NO. 3

AMENDMENT

UNITED STATES PATENT OFFICE  
Division 16 - Room 109MAIL ROOM  
FEB 25  
1915  
U.S. PATENT OFFICE

In re application of

Harold DeForest Arnold,

Serial No. 841,567.

Filed May 28, 1914.

Audions.

PATENT OFFICE

FEB 26 1915

DIV. 16 F. 11

COMMISSIONER OF PATENTS.

Washington, D.C.

Sir:

In response to the Office action of February 16, 1915,  
please amend the above entitled application as follows:

Cancel claims 6 and 7 and substitute therefor the  
following claims:

6. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said input electrode being arranged closer to said cathode than to said output electrode, and said output electrode and said cathode being so spaced apart as to develop output energy at a voltage differing from the voltage of the input energy by a predetermined ratio.

7. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said input electrode being arranged closer to said cathode than to said output electrode, and the amount of obstruction offered by said input electrode being so low and the output electrode being arranged so close to said cathode as to develop output energy at a voltage lower than the voltage of the input energy by a predetermined ratio.--

Claim 8, last line change "ratio" to --ratio.--

A reconsideration of claims 3 and 4 without amendment is respectfully requested.

Claims 6 and 7 have been rewritten to free them from the objections specified in the Office action.

Claims 3, 4, 6 and 7 are believed to clearly distinguish from the Pierce and Schlosmitch et al. patents of record.

It is evident that Pierce, in stating that the voltage of the battery depends upon certain factors means that in operating a given device the best value of the D.C. of battery voltage can be found by trial and that the variation of distances and mesh would vary this best or most suitable battery voltage.

Claims 3, 4, 6 and 7 are directed to the ratio of available output alternating current voltage to the input alternating current voltage. This, in accordance with applicant's invention, is entirely independent of the direct current or battery voltage, (the alternating current voltages being always kept, of course, within reasonable limits). Pierce nowhere refers to the ratio of alternating current voltages nor does his patent give any hint of the possibility of such ratio being predetermined. He merely mentions a means by which a given device can be made to operate as satisfactorily as possible in a given circuit, and states that this adjustment varies with the device in question.

In the patent to Schlosmitch et al., it is stated that the "amplitude" depends upon the potential of the auxiliary source of current, (Page 1, lines 102-103). Thus the voltage of the battery or source of direct current is called upon to produce the "amplitude". Applicant, of course, uses a battery in connection with his thermionic repeater and naturally adjusts the battery to a correct value, but he constructs the tube to get "amplitude". For example, in accordance with applicant's invention, it is possible to have two tubes in connection with which batteries or sources of direct current having the same voltages may be employed and having the same input alternating current voltage, and



1266

nevertheless in the case of one tube obtain an "amplitude" a thousand times that in the other. In the case of applicant's invention, battery or direct current voltage is incidental and it is the structure of the tube which is fundamental.

An allowance is respectfully requested.

Respectfully,

HAROLD DEFOREST ARNOLD,

By Attorney

Attorney.

463 West Street,

New York, Feb 24, 1915.

841 20

24:AL

-3-

Div. 16 Room 109

Division of Patent,  
Washington, D. C.,  
to be filled by name.

2-200

Paper No. 2

All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

1267

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

Mar. 10, 1915.

Mr. John G. Roberts,

463 West Street,

New York, N. Y.

PATENT OFFICE  
MAR 10-1915  
MAILED

Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 641,567, filed May 28, 1914.

Audions.

Thomas Ewing  
Commissioner of Patents

This action is in response to amendment filed Feb.  
25, 1915.

In response to applicant's argument, it is noted that the amplitude of the variation of the current in the out-put circuit of an audion is produced by the audion, and the examiner does not deny that applicant can obtain a greater current amplitude variation by means of the improvements disclosed. The amount of current variation is, however, not dependent upon the voltage in the out-put circuit, but is caused by the variation in the impedance of the audion. Applicant's argument seems to be based on the ground that he obtains a greater current variation (line 4 from the bottom of page 3), rather than upon any improved voltage conditions. Claims 3, 4, 6 and 7, however, are drawn in terms of voltage characteristics and the examiner is still of the opinion that the out-put voltage depends upon the voltage of the battery in the out-put circuit.

In regard to claim 4, it is still thought to be obvious, especially in view of the disclosure in Schloe-



841,567 -- 2.

much and Pierce, that the impedance drop between a cathode and anode of an audion varies with the distance therebetween and that to merely reduce the resistance to a point where the impedance is less than a certain amount does not amount to invention.

The fact that the characteristics of the audion can be predetermined adds no patentability whatsoever to the claims. Applicant might be able to mathematically calculate the characteristics of each audion in the art, but he could clearly not obtain a second patent on an old tube merely because he could determine its characteristics.

The claims should distinguish from the references by structural limitations. At present claims 3 and 4 do not distinguish in structure from the reference in any way. Claims 6 and 7 distinguish therefrom only in reciting that the in-put electrode is arranged closer to the cathode than to the anode. This alone is held not to be a patentable distinction.

*W. A. Kinnear*  
Examiner, Division XVI.

005

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Case 8

PAPER NO. 10

AMENDMENT. E

MAIL ROOM  
SEP  
22  
1915UNITED STATES PATENT OFFICE  
Division 16 - Room 109

is re application of  
 Harold DeForest Arnold,  
 Serial No. 841,567,  
 Filed May 28, 1914

Andions

PATENT OFFICE

SEP 23 1915

DIV. 16 FILED

COMMISSIONER OF PATENTS,  
 Washington, D.C.

Sir:

Following the last Office action of March 10, 1915 of this case, this specification has been rewritten with the object of making clearer the sense in which some of the terms are used and of exhibiting in quantitative form the relations which were merely described qualitatively in the original specification.

Please cancel the original specification and substitute therefor this one.

Claims 1, 2, 3 and 4 are those which have been allowed as Nos. 1, 2, 3 and 4 of the original specification, and in addition, claims 5 and 6 have been added which are now thought to be free from the objections made to claims 5 and 7 of the original specification.

REMARKS

The point of view of the Examiner, in arguing that the electromotive force of the output battery is one determining factor in the output voltage, is appreciated, and it has therefore been more specifically pointed out in the specification that



(Serial No. 841,567)

since it is the structure only which is the subject of the claims, only those changes in output voltage or current, which are due to changes in the structure itself, were in the mind of the inventor in this case. He is, of course, aware of the influence of battery voltage upon the characteristics of the device, having been, we believe, the first to make any scientific study of the audion amplifier. It is, however, impossible to secure the desired characteristics by a change in the single variable of battery, but the structure itself must be changed as described in this specification.

The terms "output voltage" and "output current" have been defined in the revised specification, these definitions indicating in precise form the sense in which these terms are understood and used in the art.

Respectfully,

HAROLD ROBERT ARNOLD,

By J. Roberts  
Attorney.

443 West Street,

New York, Sept 21, 1918

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JH

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PATENT OFF

SEP 23 19

DIV. 16 FILED

MAIL ROOM  
SEP  
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1916  
U.S. PATENT OFFICE

24  
25 TO ALL WHOM IT MAY CONCERN:

26 Be it known that I, HAROLD DeFOREST ARNOLD, a citizen  
27 of the United States, residing at East Orange, in the County of  
28 Essex and State of New Jersey, have invented certain new and  
29 useful improvements in AUDIOMS, of which the following is a  
30 full, clear, concise and exact description.

31 This invention relates to  
32 thermionic amplifiers of the audion type.



1 and its object is to provide a structure by which certain desired  
2 characteristics of the amplifier may be secured at will and in an  
3 efficient manner. This object is accomplished by proportioning  
4 the geometrical and electrical relations of the various elements  
5 of the device in a manner more fully explained later in this  
6 specification.

7 In order that the novelty of this invention may be  
8 appreciated, and that those skilled in the art may be enabled  
9 to use this invention to best advantage, it is necessary that  
10 certain terms hereinafter used shall be defined. The following  
11 brief discussion is intended to explain the operation of the  
12 device and to define the terms to be employed.

13 The thermionic amplifier consists of a hot electron-  
14 emitting cathode, such as the so-called "Wahmelt" cathode, of a  
15 cool anode and of an auxiliary electrode called the grid, which  
16 is usually, though not always, located between the anode and the  
17 cathode. A battery is connected so as to force the electrons  
18 liberated at the cathode toward the anode, thus setting up a  
19 convection current carried by electrons in the evacuated space.  
20 In this specification, since the structure only is under discussion,  
21 only the effects of changes in the structure itself are considered.  
22 Obviously a change in the battery will also change the characteris-  
23 tics of the circuit, but in a way which is already known in the art.  
24 Due to the presence of these electrons, a negative space charge is  
25 established between the anode and the cathode, whose effect is to  
26 limit the number of electrons which can leave the cathode, and  
27 consequently to limit also the current which can flow in the out-  
28 put circuit, by which is meant the circuit including the battery  
29 and the path of the space current. The object of the grid is to  
30 furnish a means for introducing a further negative charge into  
31 the space between the anode and the cathode, or for introducing  
32 into it a positive charge which shall neutralize the effect of

1 part of the space charge due to the electrons. In the first case,  
2 the convection current is decreased; in the second it is increased.  
3 In order to force this charge to the grid, a source of electro-  
4 motive force is connected between grid and cathode, that is, between  
5 the input terminals of the device. The effect of such an impressed  
6 electromotive force is therefore to alter the magnitude of the  
7 space current in the amplifier by changing the distribution of  
8 space charge between the electrodes, and moreover this is accom-  
9 plished without requiring that the impressed electromotive force  
10 shall do more work than that involved in forcing the charge to  
11 the grid against the counter voltage of the condenser formed by  
12 grid and filament. Since in this operation the change in power  
13 contained in the output circuit may be much greater than that re-  
14 quired in charging the condenser, the device acts as an amplifier.  
15 This variation in space current, due to an impressed electromotive  
16 force, will hereafter be called the output current of the amplifier  
17 and the variation in voltage, which appears in the output circuit  
18 due to the impressed electromotive force, will be called the output  
19 voltage. The reason for adopting these definitions is that in the  
20 practical applications of the amplifier it is only these variations  
21 in current or voltage which are utilized; in fact, a transformer is  
22 ordinarily used to derive power from the output circuit, and  
23 obviously the steady space current or the steady output voltage  
24 have no effect in the secondary of that transformer and may be  
25 ignored for practical purposes. Thus, the term voltage amplifica-  
26 tion means here the ratio of the alternating voltage appearing in  
27 the secondary of such a unity ratio transformer to the alternating  
28 impressed voltage, when the transformer primary is made to include  
29 the whole of the output circuit external to the amplifier. In  
30 simpler terms, it is the ratio of the above defined output voltage  
31 to the impressed input voltage.

32 There will also be occasion to consider the ratio of



1 output current to input voltage, the latter being taken as  
 2 standard throughout. When this ratio is high, other things  
 3 being the same, the amplifier will be said to be of the high  
 4 current type, and vice versa. This latter ratio is, of course,  
 5 not a pure number, but is of the nature of an admittance.

6 It has been found that amplifiers may be designed to  
 7 have predetermined values of these ratios. For example, one may  
 8 be designed to deliver from its output circuit a comparatively  
 9 high voltage with a low current, or vice versa. In the first  
 10 of these two cases the output circuit would have a high alternating  
 11 current impedance, and would therefore be adapted for use in  
 12 connection with a high impedance circuit. For example, it could  
 13 be used efficiently to work into the input circuit of another  
 14 element, since that circuit has ordinarily a very high resistance.  
 15 In the second of these cases the impedance of the output circuit  
 16 would be lower and the amplifier would be suitable for use in  
 17 connection with telephone lines, submarine cables, etc. In this  
 18 connection it should be recalled that the maximum amount of power  
 19 is transferred from one given circuit to another when the re-  
 20 sistance of the second is made equal to that of the first.

21 Now, it has been found that for a given anode, cathode  
 22 and output battery, the voltage amplification ratio depends upon  
 23 the distance,  $g$ , from grid to anode, upon the internal resistance  
 24  $r$  of the amplifier, upon the external resistance  $R$  of the output  
 25 circuit, and upon the character of the grid, all in the manner  
 26 expressed by the formula:

$$27 \quad \frac{E}{K} \cdot \frac{1}{1 + \frac{R}{r}} \text{ ----- (1)}$$

28  
 29  
 30 in which  $K$  is a constant which depends upon the grid structure; in  
 31 particular the number  $K$  is larger, the larger the ratio of open  
 32 space in the grid to its conducting surface. It may be calculated

1 from the electrical and geometrical data of the system. The  
 2 internal resistance  $r$  depends upon the areas and distance apart  
 3 of anode and cathode, and, for the sake of efficiency, should be  
 4 kept small by using a large cathode area, that is, a long filament,  
 5 and by arranging the anode and cathode as close to one another as  
 6 is consistent with conditions to be given later. It has also been  
 7 found that this ~~external~~ <sup>internal</sup> resistance is proportional, for a given  
 8 structure, to the square of the voltage amplification on open  
 9 output circuit. Thus:

$$r \propto \left(\frac{E}{K}\right)^2 \dots \dots \dots (2)$$

13 From the formulae 1 and 2 follow the conditions to be satisfied  
 14 in order that the amplifier may have given characteristics. Thus,  
 15 if one of high voltage amplification is required, it will be  
 16 necessary to make the distance from grid to plate large, the dis-  
 17 tance from grid to cathode small, the cathode area large and the  
 18 mesh of the grid fine, that is, the ratio of open space to conductor  
 19 area in the grid should be small. On the other hand, if it is  
 20 desired to obtain a large current output, these formulae require  
 21 that the distance from grid to plate shall be small, that that  
 22 from grid to cathode shall be small, that the cathode area shall  
 23 be large and that the mesh of the grid shall be coarse, that is,  
 24 the grid should screen as little of the plate as possible when the  
 25 latter is viewed from the cathode. Examination of these conditions  
 26 shows that increasing the voltage amplification by adjusting the  
 27 grid and plate decreases the current, and vice versa, so that the  
 28 device acts in this respect much like an alternating current trans-  
 29 former. It has been found possible by using these relations to  
 30 construct amplifiers which shall display characteristics which  
 31 have been assigned beforehand.

32 The structural details of this invention will now be



more fully described in connection with the drawings in which  
 Fig. 1 represents the structure of an amplifier having a high  
 voltage amplification and a correspondingly low output current  
 capacity; Fig. 2 is a plan view of the amplifier of Fig. 1  
 arranged to exhibit the geometrical configuration; Fig. 3 is a  
 view of a structure designed to give a high output current; Fig.  
 4 is a plan view of the structure of Fig. 3; Figs. 5 and 6 are  
 views corresponding to Figs. 3 and 4, respectively, of a modified  
 structure of the aforementioned new type of amplifier. In these  
 figures, like numerals represent corresponding parts.

Referring to Figs. 1 and 2, 1 represents the grid element, 2 the cathode or filament and 3 the anode or plate. The plate is placed a considerable distance from the cathode, and to make the distance  $d$  from plate to grid as large as possible without at the same time increasing the resistance of the tube, the grid is placed as close as possible to the cathode, and it is preferably separated from the latter only by a thin insulating film which may be, for example, an oxidizing coating upon one or other of these elements. Farther, as indicated by the structure of the formula 1, the grid is made to have a close mesh and thus to obstruct greatly the view of the plate as seen from the cathode. An amplifier, constructed as here illustrated, will have for a given input voltage a high output voltage and a low output current, these terms being interpreted as defined above. It will therefore be suitable for operation in connection with high impedance circuits.

Figs. 3 and 4 are two views of thermionic amplifiers of the high current type. In these structures, in conformity with the conditions already given, the distance from plate 3<sup>a</sup> to grid 1<sup>a</sup> is made as small as possible, as is also that from grid to filament 2<sup>a</sup>. Farther, the grid is made to have a coarse mesh, or is constructed so that the ratio of open space to the

projected area of the grid shall be large as required by the conditions explained for this type of amplifier. A particular amplifier, constructed in accordance with these specifications, has been observed to give an output voltage as here defined, only one-third of the input voltage with a correspondingly high current, the effect being to make the apparent impedance of the output circuit as low as 500 ohms. This is in contrast to the high-voltage, low-current type which more closely resembles previously constructed amplifiers, and in which the voltage amplification is much greater than unity and the output impedance very large - so large that such an amplifier cannot be worked efficiently into an ordinary telephone line or similar circuit without the use of high ratio transformers.

Figs. 5 and 6 show another modification of the high current type of amplifier. In these figures the input electrode or grid is in the form of a wire  $P^b$ , bent back at its middle. In effect, therefore, the input electrode consists of two wires joined together. The filament  $S^b$  is wound about the input electrode and is insulated therefrom by a tube of insulating material 4, an arrangement which is not the invention of this applicant, *Patent 1,169,432, of January 25, 1916, to* ~~but is described and claimed in a co-pending application~~ ~~is the name of Alexander McLean Nicolson, Serial No. 345,808, filed September 25, 1914 and assigned to the same assignee as the present application.~~ The output electrode or anode consists of two plates  $S^a$ ,  $S^b$  arranged upon opposite sides of the filament and close to it. It will be noted that the input electrode is not located between the filament and the plate, such not being necessary for efficient action in this high current type of amplifier. In all these amplifiers, the condition of most efficient operation requires that the resistance of the device shall be as small as possible and, consequently, irrespective of the distance of plate from cathode.



1 that the distance from grid to cathode shall be made as small  
2 as possible without encountering mechanical difficulties.

3 The novel features of this invention lie in so  
4 arranging the various elements as to secure this efficient  
5 action, while at the same time securing those voltage, current,  
6 and impedance characteristics which are desired.

7

8

31

32

## WHAT IS CLAIMED IS:

1. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode in immediate proximity to said cathode but out of electrical contact therewith and closer to said cathode than to said output electrode.

2. A thermionic repeater having its cathode and its output electrode spaced apart a distance suitable for producing a desired ratio of output voltage to input voltage and having its input electrode as close as possible to said cathode without contacting therewith and closer to said cathode than to said output electrode.

*See H*  
~~3. A thermionic repeater having its output electrode arranged so close to its cathode as to develop output energy at a voltage lower than the voltage of the input energy and having its input electrode arranged closer to said cathode than to said output electrode.~~

~~4. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said input electrode being arranged much closer to said cathode than to said output electrode, and said output electrode and said cathode being so spaced apart and the amount of obstruction offered by said input electrode being such as to develop output energy at a voltage differing from the voltage of the input energy by a predetermined ratio.~~

~~5. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said input electrode being arranged closer to said cathode than to said output electrode, and~~



said output electrode and said cathode being so spaced apart as to secure a predetermined ratio of output voltage to input voltage of said repeater.

6. A thermionic repeater comprising an input electrode, an output electrode and a heated cathode, said input electrode being arranged closer to said cathode than to said output electrode, and the amount of obstruction offered by said input electrode being so low and the output electrode being arranged so close to said cathode as to produce a predetermined ratio of output voltage to input voltage of said repeater.

*Insert 53*

15 Repts. 109  
and not be subject to same.

2-222

Page No. 11  
An examination of the application  
has been made and the following  
observations, criticisms, and  
suggestions are made.

1281

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

Oct. 26, 1915.

Mr. John G. Roberts.

463 West St.

New York, N. Y.

U. S. PATENT OFFICE  
OCT 26 1915  
MAILED 20

Please find below a communication from the EXAMINER in charge of the application of

H. DeF. Arnold, S. No. 842,857, filed May 28, 1914.

Answers.

Thomas Ewing  
Commissioner of Patents

This action is in response to amendment filed  
Sept. 12, 1915.

The following reference is added to the record:

VonLieben et al, reissue 13,779, July 21,  
1914, 179 - 171.

The new specification and claims have been sub-  
stituted for the old.

Claims 3, 4, 5 and 6 are each rejected on the  
patent to vonLieben et al, above cited, which shows  
in Figure 1, for example, an input electrode H ar-  
ranged much closer to the cathode K than to the out-  
put electrode A. These claims are therefore square-  
ly met in structure and the function recited is in-  
sufficient to carry the claims for two reasons:  
first, it is a well settled rule that a claim to be  
allowable must distinguish from the prior art by  
structure and not merely by functional statements;  
secondly, it is thought to be old to operate a thermionic  
repeater with an output voltage, such as defined in the  
new specification, lower than the input voltage. In



this connection attention is directed to the specification of VonLieben et al, and particularly to the paragraph on page 2, beginning in line 41, in which it is stated that the variations of current and voltage in the output circuit are very low unless the voltage of the battery in the input circuit, the pressure of the gas in the tube, the temperature of the cathode, etc., are adjusted to the proper value. It appears to be clear that the repeater of VonLieben et al when adjusted so that the variations of current in the output circuit are small would produce an output voltage lower than the input voltage, the output voltage being defined as the variation in voltage in the output circuit, since the variation in voltage or potential difference across the secondary in the output circuit would be small when the variation of current in this circuit is small.

Claims 1 and 2 stand allowed.

*John A. Kuman*  
Examiner, Division XII.

CS

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Div. 16 Room 109

The Commissioner of Patents,  
Washington, D. C.,  
and not any official by name.

2-222



Paper No. 12

All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

Copy sent  
applicant  
and as-  
signee.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

Oct. 14, 1916.

PATENT OFFICE

OCT 14 1916

MAILED

Mr. John G. Roberts,

445 West Street,

New York, N. Y.

Please find below a communication from the EXAMINER in charge of the application of

H. D. Arnold, A. No. 841,567, filed May 28, 1914.

Auditions.

Thomas Ewing  
Commissioner of Patents

In view of an interference the following  
claims, readable upon Figures 5 and 6, are sug-  
gested to applicant:

An anode having input and output elec-  
trodes and a filament, one of said three mem-  
bers having the form of a helix and being lo-  
cated between the other two of said members.

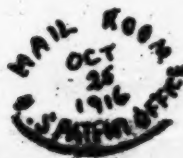
An evacuated vessel containing three elec-  
trodes, one of which is a filament, one of said  
electrodes having the form of a helix and being  
located between the other two of said members.

An evacuated vessel containing three elec-  
trodes, one of which is a filament, one of said  
electrodes forming a hollow cylinder having for  
its axis a discontinuous surface and containing  
within it one of the other two electrodes, the  
third electrode being located outside the cylin-  
drical member.

A period of thirty days is granted appli-  
cant in which to overcome the Hull patent and pre-  
sent the above claims.

W. A. K.  
Chas. F. Lewis  
Asst. Examiner, Division XVI.





PAPER No. 13  
AMENDMENT 7

UNITED STATES PATENT OFFICE  
DIVISION 16, Room 109

In re application of  
HAROLD DEFOREST ARNOLD  
Serial No. 641,547  
Filed May 20, 1914

Audience

PATENT OFFICE  
OCT 26 1916  
Div. 16, Room 109

COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

This amendment is in response to Office action of  
October 26, 1916.

✓ Page 5, line 7, change "external" to --internal--;  
same page, line 29, after "transformer" insert the following:

--It is thus seen that the voltage amplification is  
directly proportional to the distance between the  
anode and the grid and that it is also proportional  
to the reciprocal of the constant K, as defined above.  
It is to be understood, however, that in using the  
term "directly proportional," it is not intended to  
imply that the proportion is mathematically exact,  
but that the term is used in contradistinction to,  
inversely proportional--.

✓ Page 7, lines 21 and 22, cancel "a re-pending  
application in the name of", and substitute --patent 1,169,422  
of January 25, 1916, to--. Cancel the remainder of the  
sentence commencing with "Serial No." in line 22,

✓ Cancel claim 3, and substitute the following:

3 --a thermionic repeater having its output and input

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my white lined work*

*Rev  
H. L. 2*

(Serial No. 841,847)

--electrodes so spaced with respect to each other and to the cathode as to develop output energy at a voltage lower than the voltage of the input energy, but with a large current value--.

Add the following claims:

7. A thermionic device for the amplification of electrical energies comprising a heated cathode and an anode, means for establishing an electric field between said cathode and anode whereby an electron stream is caused to flow therebetween, and an input electrode partially obstructing the passage of said electron stream, the degree of said obstruction being directly proportional to the preassigned voltage transformation component of said energy amplification.

8. In a thermionic device for the amplification of electrical energies, an input electrode comprising a conducting grid, the ratio of conducting surface to open space in said grid being directly proportional to the preassigned voltage transformation component of said energy amplification.

9. A thermionic device for the amplification of electrical energies comprising a cathode, an anode and a conducting grid, the ratio of conducting surface to open space in said grid and the distance between said anode and said grid being each directly proportional to the preassigned voltage transformation component of said energy amplification--.



(Serial No. 841,847)

REMARKS

Claims 3 to 6 have been rejected on patent to Von Lieben et al. It is true, as the Examiner states that Von Lieben shows a grid element which is located closer to the filament than to the anode, but it is respectfully urged that in doing so Von Lieben had no such conception regarding the value of so locating the grid or the value of changing its position, or of changing its anode, as has been disclosed in the invention of this applicant. It is true also that as Von Lieben points out his device may, under certain conditions, operate very inefficiently, in which case the output energy will be very low. It is to be observed, however, that when the output voltage decreases it is accompanied by a corresponding decrease in the output current. This, of course, is what will happen in any ordinary vacuum tube repeater, including the ones shown by applicant. As pointed out fully in his specification, the applicant has in mind a totally different effect, namely, that if the elements within the tube have a certain relative position with respect to each other, and that then certain changes are made in this relative position the voltage amplification for example will be increased, but in this case the current amplification will be decreased, or, on the other hand, if certain other changes are made the voltage amplification will be decreased, but the current amplification will be increased. In other words, it is not a question of the efficiency of operation of the tube, but rather the arrangement of the elements in such a manner that the tube will have those desired electrical characteristics

whereby it may be possible to construct a repeater which will be adapted for certain purposes.

With this in mind, the applicant has cancelled claim 3, and substituted therefor a claim which it is thought will bring out this feature by stating that when the voltage amplification is low the current will be large.

A reconsideration of claims 4, 5 and 6 in their present form is requested. In view of the fact that these claims state that the output voltage shall differ from the input voltage by a predetermined ratio, it is thought that the claims clearly distinguish from Von Lieben. No intimation whatsoever is contained in the Von Lieben specification which would teach any one that a tube could be constructed which would give a pre-determined ratio of output and input voltage. Von Lieben merely points out that it is desirable to maintain his grid at a certain voltage potential with respect to the filament in order to obtain reasonably efficient operation, and such an invention is not in any way connected, or associated, with the invention which the applicant has endeavored to set forth in these claims 4 to 6. This matter of pre-determining the ratio of the output and the input voltage is not merely a matter of mathematically calculating the characteristics of any audion in the art, but relates to, and, states the fact, that having previously determined what characteristics are desired in a repeater it is then possible by following certain rules, as laid down in this specification and claims, to construct a repeater which will have these desired or pre-determined characteristics.

No information of such a character is even hinted at by

7/3/49



(Serial No. 841,587)

Von Lieben or the other references which have been made  
a part of this record.

In addition to the claims previously in the  
record, claims 7 to 9 have been added and it is thought that  
these claims are plainly allowable over the references cited.

Respectfully,

HAROLD DEFOREST ARNOLD

*W. J. Roberts*  
Attorney

463 West Street,

New York,

Oct 24, 1916

174:30  
174:30

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1916  
U.S. PATENT OFFICE

PAPER No. 14

AMENDMENT *G*

UNITED STATES PATENT OFFICE  
Division 14 Room 109

In re application of  
Harold DeForest Arnold  
Serial No. 841,557  
Filed May 29, 1914

Audions

PATENT OFFICE  
NOV 14 1916

COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

This amendment is in response to Office action of  
October 14, 1916.

✓ Add the following claims:

*Paul G.*  
3 -- 10. An audion having input and output electrodes and a filament, one of said three members having the form of a helix and being located between the other two of said members.

4 -- 11. An evacuated vessel containing three electrodes, one of which is a filament, one of said electrodes having the form of a helix and being located between the other two of said members.

5 -- 12. An evacuated vessel containing three electrodes, one of which is a filament, one of said electrodes forming a hollow cylinder having for its area a discontinuous surface and containing within it one of the other two



1200

Serial No. 841,867

electrodes, the third electrode being located  
outside the cylindrical member.--

**REMARKS**

The last sentence of the Office action relating  
to overcoming the Hall patent is not understood inasmuch as  
no Hall patent has been cited in this application. Further  
information is requested.

Respectfully,

HAROLD DeFOREST ARNOLD

By *H. DeForest Arnold*  
Attorney

463 West Street,

New York, *Nov. 11*, 1916.

*H. DeForest Arnold*

## INTERFERENCE.

13

Interference No. 40890

Page No. 15

Name, H. H. Anderson

Serial No. 357

Title, Auditor

Filed, May 28, 1914

Interference with Davis v. Belmont & Frankland  
the v. de Font

## DECISIONS OF

Primary Examiner, \_\_\_\_\_ Dated, \_\_\_\_\_

Ex'r of Interferences, \_\_\_\_\_ Dated, \_\_\_\_\_

Board, \_\_\_\_\_ Dated, \_\_\_\_\_

Commissioner, \_\_\_\_\_ Dated, \_\_\_\_\_

## REMARKS:

Feb 23 1917 Reissue application of Nielsen  
substituted for AndersonThis should be placed in each application or patent involved in interference in addition to the interference notice  
by Primary Examiner.



1292

Forwarded from No. 16 to  
Director of Interference.

Dec. 9, 1916.

2-215

Page No. 16.

P.O. [unclear]

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C.

A

Copy sent assignee.

Mr. John D. Roberts,

445 West Street,

New York, N. Y.

U. S. PATENT OFFICE  
INTERFERENCE

DEC 10 1916

MAILED

Please find below a copy of a communication from the Examiner concerning the  
application of E. DeP. Arnold, S. No. 841,567, filed  
May 28, 1914, Audions.

Room No. 109

ADDRESS ONLY  
THE COMMISSIONER OF PATENTS  
WASHINGTON, D. C.

Very respectfully,

Thomas Ewing

40890

Commissioner of Patents

The case, above referred to, is adjudged to interfere with others, hereafter specified,  
and the question of priority will be determined in conformity with the Rules.

The statement demanded by Rule 119 must be called up and filed on or before

JAN 29 1917

, with the subject of the invention, and name of  
party filing it, indorsed on the envelope. The subject-matter involved in the interference is

1. An audion having input and output electrodes  
and a filament, one of said three members having  
the form of a helix and being located between the  
other two of said members.

2. An evacuated vessel containing three elec-  
trodes, one of which is a filament, one of said  
electrodes having the form of a helix and being  
located between the other two of said members.

3. An evacuated vessel containing three elec-  
trodes, one of which is a filament, one of said  
electrodes forming a hollow cylinder having for  
its axis a discontinuous surface and containing  
within it one of the other two electrodes, the  
third electrode being located outside the cylin-  
drical member.

The interference involves your application  
above identified:

An application for Audions, filed by Loe  
deForest, 1301 Sedgwick Avenue, New York, N. Y.,  
whose attorney is Philip Farnsworth, 140 Broadway,  
New York, N. Y.;

641,547 -- 2.

An application for Oscillation Responsive Device, filed by Otis B. Moorhead and Ralph C. Hyde, 1229 Myrtle St., Oakland, Calif., and 1719 Ninth St., Alameda, Calif., respectively, whose attorneys are White and Frost, Crocker Bldg., San Francisco, Calif.;

An application for Ionised-Chamber Devices, filed by Clifford D. Babcock, 19 East 18th St., New York, N. Y., whose attorney is Clair W. Fairbanks, 85 Liberty St., New York, N. Y., and whose assignee is John Heilsen, New York, N. Y., and

An application for Radio Detector, filed by Richard J. Davies, Jr., 334 4th Street, Weehawken, N. J., whose attorneys are H. E. Freeman & Co., Warder Bldg., Washington, D. C.

The relation of the counts of the interference to the claims of the respective parties is as follows:

Counts: Davies: Babcock: Moorhead: deForest: Arnold:

1	8	23	34	5	10
2	10	25	26	6	11
3	12	27	28	9	12

*W. E. Kinnear*  
Examiner, Division XVI.



1294  
Div. 12, Room 112

Address only  
"The Commissioner of Patents,  
Washington, D. C."  
and call my attention by name.

E.R.

2-205

Page No. 12

All communications respecting this  
application should give the serial number,  
date of filing, title of invention, and  
name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

July 31, 1917.

John G. Roberts,

465 West St.,

New York, N.Y.

U. S. PATENT OFFICE

JUL 31 1917

MAILED

Please find below a communication from the EXAMINER in charge of this application of

Harold DeForest Arnold, S. No. 341,667, filed May 22,

1914, for Antenna.

Thomas Ewing  
Commissioner of Patents

This case has been considered as amended  
Oct. 25, 1916 and Nov. 13, 1916.

As another application has been substituted  
for this application in Interference No. 40,890,  
claims 10, 11 and 12 should be canceled.

Claims 3 to 9 are rejected as unpatentable in  
view of the reissue patent No. 15,779, Van Leiben,  
of record. Claim 3 is also met by the antenna  
disclosed on pages 64 and 65 of "The Wireless  
Telephone" of record. These references show  
the structure called for by the claims and the  
statement of function is considered insuffic-  
ient to patentably distinguish from the refer-  
ences. Applicant's discovery appears to be the  
law governing the positioning of the elements  
for a desired output from the antenna but that  
is no ground for the allowance of claims drawn  
to a structure that is now old in the art.

Pat. 557 --2.

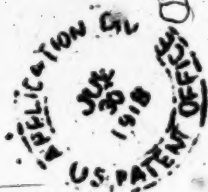
As this case has been pending for more than three years and the matter of these claims has been several times considered, this rejection is made final. The examiner will, however, admit any amendment that will put the case in condition for allowance.

*W. A. Kuman*

Examiner, Division XVI.



1296



UNITED STATES PATENT OFFICE.

Division 16 Room 109

PAPER NO 19

AMENDMENT 147

In re application of

Harold DeForest Arnold

Subject

audions

Serial No. 841,567

Filed May 28, 1914

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

JUL 31 1918

Sir:

In response to the Office action of July 31, 1917.

Cancel claims 3 to 9 inclusive and renumber claims

10 to 12 inclusive as 3 to 5 inclusive.

REMARKS

The rejected claims have been cancelled.

A continuing application is being filed on this same date. The subject matter of the claims which are cancelled according to this amendment, is being presented in the continuing application, in new claims which it is believed are clearly allowable. Applicant desires it to be understood that he is not abandoning the subject matter of these claims, but is merely transferring it to the continuing application.

Respectfully,

HAROLD DEFOREST ARNOLD,

By A. C. Arnold  
Attorney

463 West Street,

New York, July 29, 1918.

1297

Div. 16 Room 112

C.N.D.

2-200

Paper No. 20

The Commissioner of Patents  
Washington, D. C.  
and not any other office

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE

WASHINGTON

August 29, 1918.

Mr. John G. Roberts.

463 West Street,

New York, New York.

AUG 29 1918

and this is a communication from the EXAMINER in response of the application of  
Harold de Forest Arnold, 841,567, filed May 28, 1914, for  
Audions.

James E. Newton  
Commissioner of Patents

This action is in response to amendment of July 30,  
1918.

In responding to the last office action no attention was paid to the requirement that claims 10, 11 and 12, now claims 3, 4 and 5, which have been inserted in another application, should be canceled from this application. The amendment, therefore, does not place this application in condition for allowance or appeal and the application is abandoned for failure to make a proper response within a year from the previous office action.

W. S. Sackman  
Examiner, Division 16.

Rust



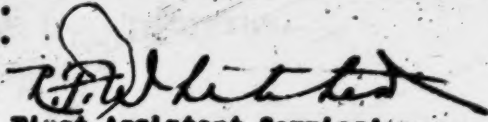
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Recorded Vol. 128, p 154.

Harold DeP. Arnold.  
No. 841,567...

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The showing made is held to establish that the delay in the prosecution of the application was unavoidable within the meaning of Sec. 4894 R. S.  
The petition is granted.

  
First Assistant Commissioner.

September 26, 1918.

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UNITED STATES PATENT OFFICE

In re application of  
H. D. ARNOLD,  
Serial No. 841,567  
Filed May 28, 1914

Andions

P E T I T I O N .

PATENT OFFICE  
SEP-6-1918  
DIV. 11, FILED

TO THE COMMISSIONER OF PATENTS,

Washington, D. C.

Sir:

Your petitioner avers that he is the applicant above named, that the above entitled application was filed May 28, 1914 and has been diligently prosecuted since that time, that the Office action dated July 31, 1917 was received by him finally rejecting claims 3 to 9 inclusive and stating that claims 10, 11 and 12 should be canceled; that, as appears from an affidavit of Mr. C. A. Sprague accompanying this petition, an amendment in response to said Office action was prepared by his attorney and was filed in the United States Patent Office July 30, 1918; that it was the full intention of his attorney to comply with all the requirements of said Office action in every particular so as to place said application in condition for allowance; that such intention is evidenced by the entire tenor of said amendment as will be apparent from an inspection thereof; that by inadvertence no direction was given in said amendment to cancel claims 10, 11 and 12 which the Examiner stated "should be canceled", but instead it was directed that these claims be renumbered; and that said inadvertence was not noticed by his attorney until



1300

(Serial No. 841,567)

the receipt of the Office action of August 29, 1918 holding the application abandoned.

Therefore, your petitioner requests that said application be revived and that the accompanying amendment be entered therein to place said application in condition for allowance in accordance with the intent of applicant's amendment of July 30, 1918.

Respectfully,

H. D. ARNOLD

BY

A. C. Channell  
Attorney

463 West Street,

New York, September 4, 1918

CAS-FJ

- 2 -

1301

Case 8

PAPER NO 21

AMENDMENT



## UNITED STATES PATENT OFFICE.

Division 16 Room 112

In re application of

E. D. ARNOLD

Subject.

Serial No. 841,567

AUDIOPH

Filed May 28, 1914

PATENT OFFICE

SEP 6-1918

THE COMMISSIONER OF PATENTS,  
Washington, D. C.

Sir:

In response to the Office action of August 29, 1918, cancel claims 3 to 5 inclusive, former claims 10 to 12 inclusive.

## REMARKS

This action is taken to place this application in condition for allowance.

Through an inadvertence applicant failed to direct the cancellation of former claims 10 to 12 inclusive in the amendment of July 30, 1918. A petition is filed herewith setting forth this fact and accompanied by an affidavit asking that this amendment be entered and the application allowed.

The requirements of the Office action of July 31, 1917 have now been fully complied with. The subject matter of this case is considered of such importance that a trip to Washington was made to insure that it receive proper attention. It is therefore hoped that the petition will be granted and the application passed for issue.

Respectfully,

443 West Street,

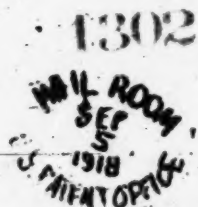
E. D. ARNOLD,

New York, September 4, 1918

Attorney

CAS-PJ





✓

#21

UNITED STATES PATENT OFFICE

In re application of  
H. D. ARNOLD  
Serial No. 842,567  
Filed May 28, 1914

Auditors

AFFIDAVIT

I, C. A. SPRAGUE, being duly sworn, depose and say:

That I am employed by the Western Electric Company, Incorporated, as a patent attorney; that I was directed by Mr. D. C. Tanner, attorney of record in the above entitled application, to prepare an amendment in response to the Office action of July 31, 1917 in said application, placing the case in condition for allowance; that in accordance with said directions I supervised the preparation of the amendment filed July 30, 1918, said amendment being prepared with the full intention of completely responding to said Office action of July 31, 1917; that due to the importance of the subject matter of this application I was instructed by Mr. Tanner to make a trip to Washington to attend to this matter and to present this amendment for filing in the United States Patent Office; that I read the said amendment after its preparation but inadvertently failed to notice that it was not completely responsive to said Office action; that the fact that said amendment was not completely responsive was not called to my attention until the receipt of an Office action dated August 22, 1918, holding the case abandoned.

C. A. Sprague

Sworn to and subscribed before me  
this 27 day of September, 1918.

Robert Williams  
Notary Public

ABS.

Paper No. 22.

## DEPARTMENT OF THE INTERIOR.

## UNITED STATES PATENT OFFICE.

Washington,

Sept. 3, 1918.

In the applic tion of  
WAROLD DeFOREST ARNOLD

Audions

Ser. No. 841,567

Filed May 28, 1914

ON PETITION

to the

COMMISSIONER OF PATENTS.

## EXAMINER'S STATEMENT

This application was held abandoned as applicant in amendment of July 30, 1918 directed the cancelation of certain claims rejected in Office letter of July 31, 1918 but did not notice the requirement in the same Office letter that claims 10, 11 and 12, now claims 3, 4 and 5, be canceled. The cancelation of these claims was required as they has been inserted in another application for the purpose of an interference. The cancelation of these claims will place the case in condition for allowance.

Respectfully,

*R.W. Smith*  
Acting Examiner, Division 16.

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WASHINGTON, D. C.

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DEPARTMENT OF THE INTERIOR  
UNITED STATES PATENT OFFICE  
WASHINGTON

September 27, 1916.

In the matter of the  
Application of  
Harold H. Arnold,  
Petitioner;  
Filed May 28, 1914  
Serial No. 841,547.

Petition to Revoke.

Sir:

You are hereby informed that the decision of  
the First Assistant Commissioner on the above petition  
is as follows:

The showing made is held to establish  
that the delay in the prosecution of this appli-  
cation was unavoidable within the meaning of  
Sec. 4924, U. S. C.

The petition is granted.

R. F. Whithead  
First Assistant Commissioner.

September 26, 1916.

By direction of the Commissioner:

Very respectfully,

Chief Clerk.

Harold H. Arnold,  
c/o John C. Roberts  
920 Broadway  
New York City.

73/66

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